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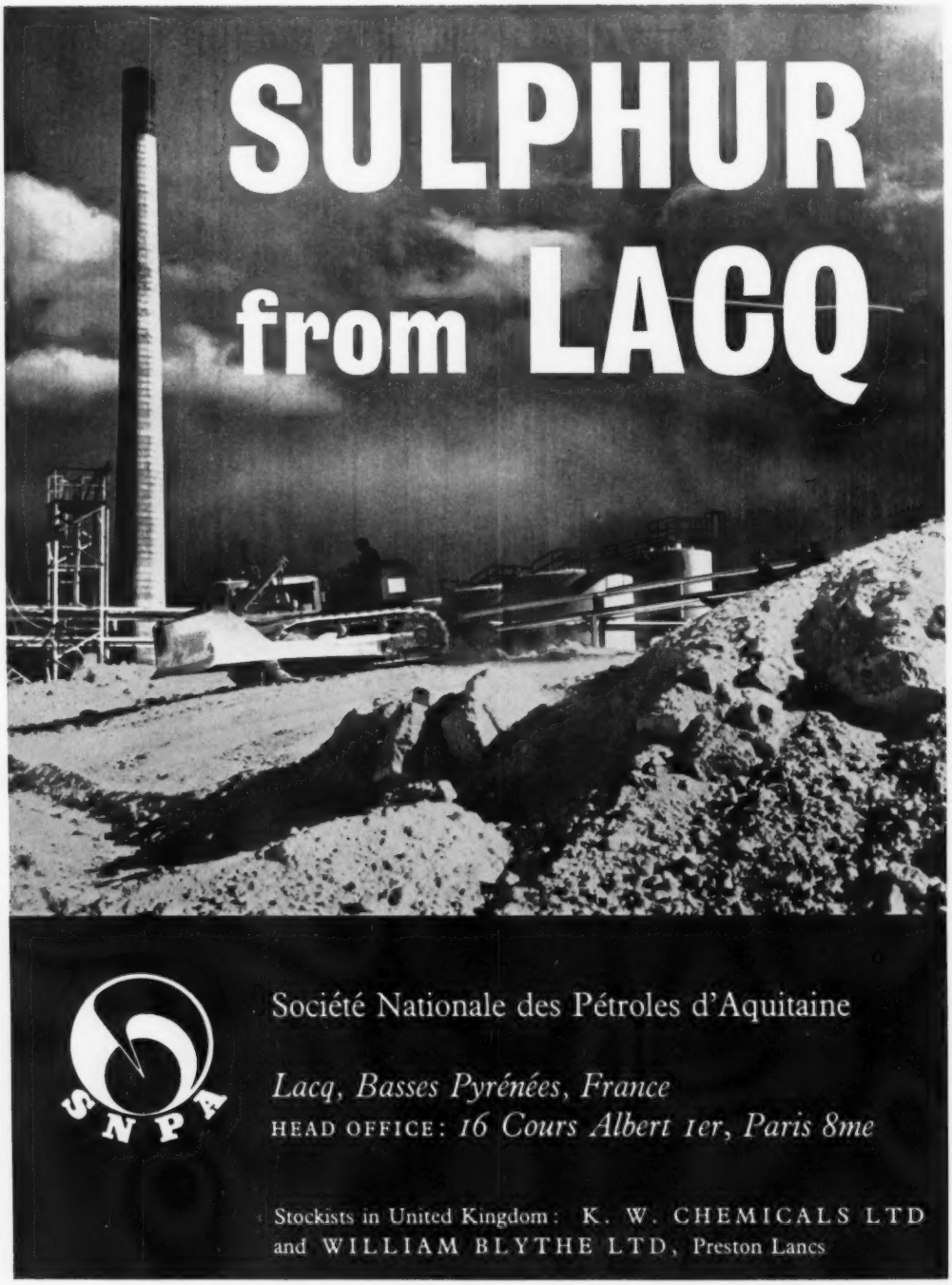
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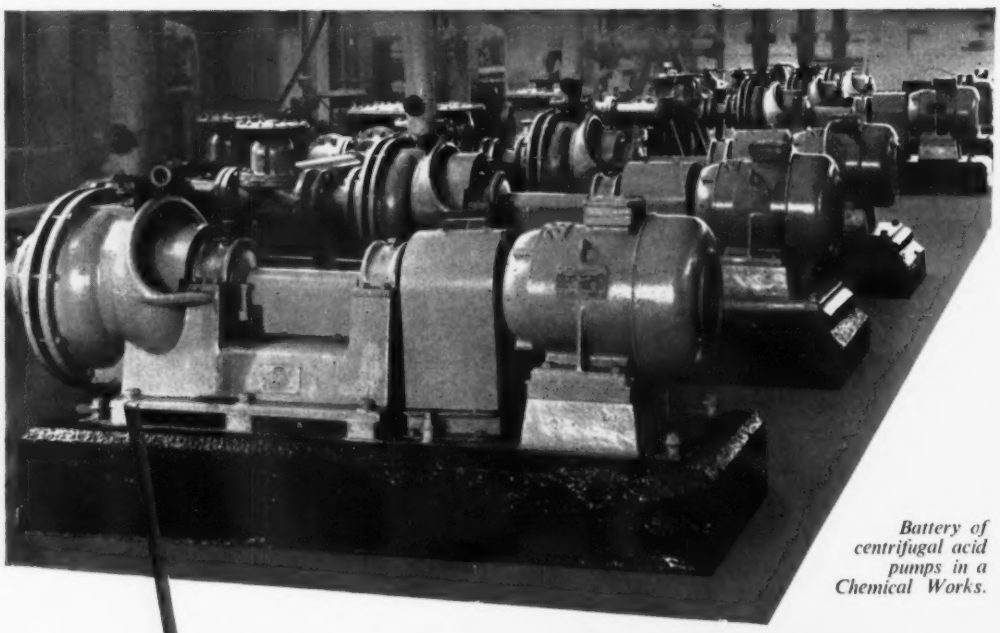

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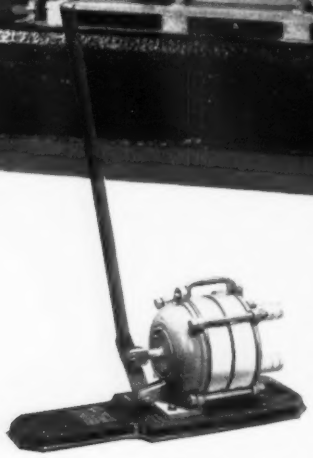

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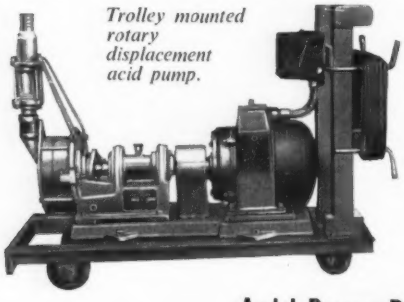

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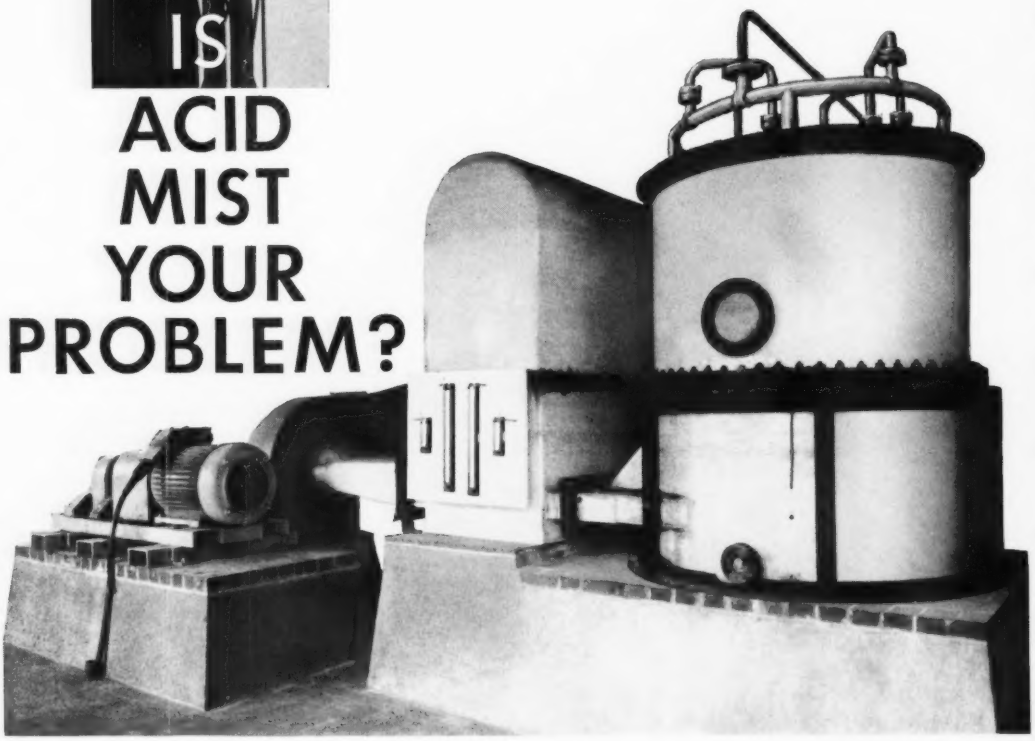

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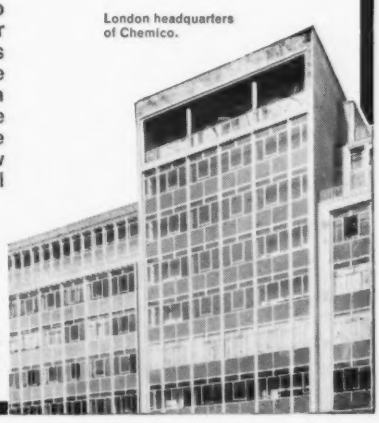

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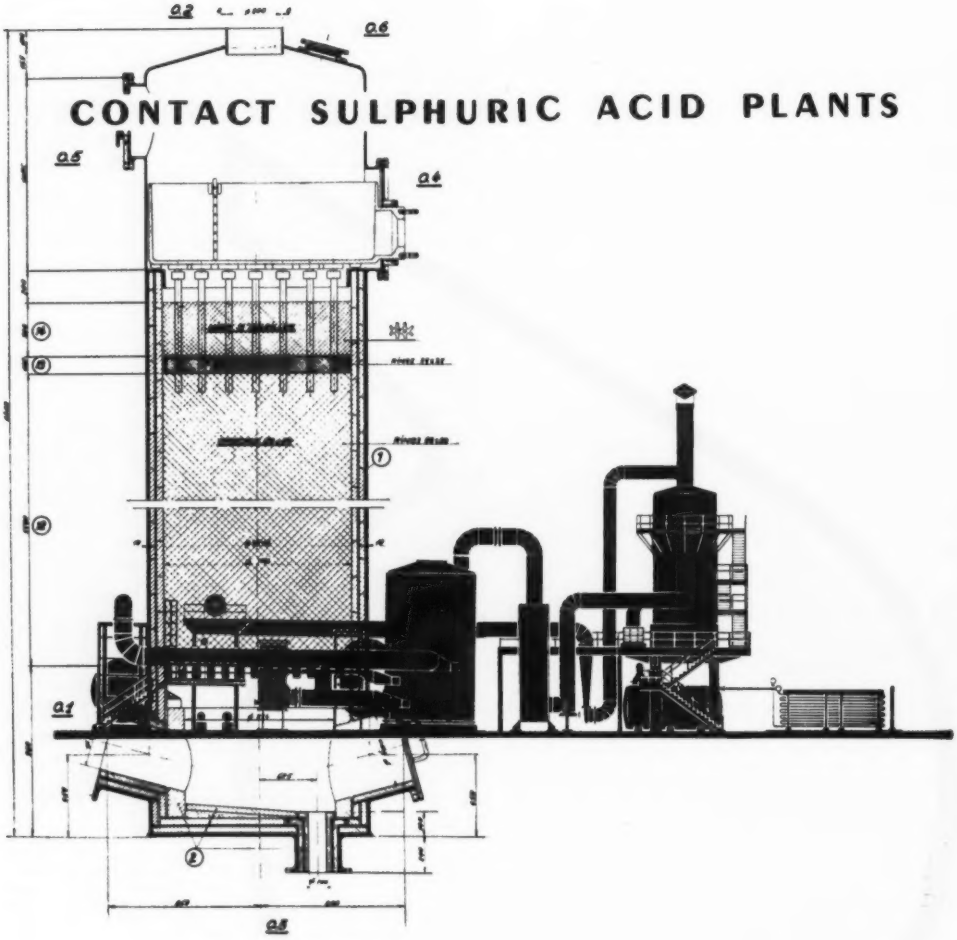

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Review

The level of world-wide sulphur demand during the first few months of this year has been high as indicated by increased output notably of Frasch sulphur, and a further reduction of stocks. Exerting the strongest pressure on sulphuric acid supplies are the needs of the fertiliser industry, which has caused acid production to reach new high levels. Other major acid using industries — viscose rayon, titanium dioxide and chemicals — reflect the high level of industrial activity.

Frasch Sulphur production remains at a relatively high level and stockpiles are being reduced. Recovered sulphur production increases progressively as more capacity in Europe and Canada comes on stream. The current supply picture, however, has not affected the tone of markets or the **price** situation which remains unstable and weak. Emphasis at present is on consumer service and quality of product. Price level of European Pyrites is unchanged. The steel industry's activity and the good copper prices provide steady support for residue values.

Titanium oxide manufacture, one of the most vigorous "growth" industries dependent on sulphuric acid and consuming annually 825,000 tons sulphur in various forms, is next to fertilisers the largest sulphur user. Its inclusion in the manufacturing pattern of all industrial countries is progressing rapidly, but the two leading producing countries, the U.S.A. which accounted for about 65%, and the U.K. representing 12% of world production in 1959 of three-quarter million tons titanium oxide, have expansion plans which will enable them to retain their present positions, while during the next 10 years world production doubles.

Now on stream is Freeport Sulphur Co's. Grand Isle sulphur dome, the world's first offshore sulphur plant. Freeport believe that the plant will eventually become a very low cost producer because the plant will be an economic one to operate; the plant is highly automated and requires fewer personnel than a similar land-based plant.

Marked economic and technical advantages have resulted from changes in the methods of roasting pyrites. These changes have been imperative from the point of view of the pyrites industry faced with the fact that brimstone is now abundantly available. Since Spain has the largest known amount of pyrites in the world, Piritas Españolas (Empresa Auxiliar de la Industria S.A.) have investigated the problems associated with pyrites roasting and contamination with arsenic and have developed a process whereby the last traces of arsenic and lead are eliminated; use of a special catalyst reduces contact time and allows a smaller furnace to be employed, and the residues obtained are suitable for the iron and steel industry. It is claimed that the process can compete with the most modern methods of roasting pyrites now in use, e.g. multi-hearth furnaces with heat recovery.

Australian sulphur consumption in 1959 again reached record levels and were, at 371,759 tons, the highest yet recorded. Indigenous sources provided 53% of the industry's raw material, brimstone consumption showing a small drop. Use of pyrites, however, increased by 2.3%. Sulphuric acid consumption showed a slight fall.

A noticeable feature is the more efficient and economic utilisation of sulphur obtained from oil refinery gases, and zinc and lead smelters.

Transportation of liquid sulphur in the U.K. has made great strides in the past three years as the result of the initiative of F. W. Berk & Co. who now operate a fleet of specially developed road tankers.

TiO_2

A major sulphur growth industry

NEXT TO CHEMICAL FERTILISERS, manufacture of titanium oxide is today the largest single user of sulphuric acid. The advance from small-scale production of a specialty product which lacked significant industrial application to the current position when titanium oxide manufacture is a major industry in at least six countries has occurred in the past 25 years. Apart from the growth of the volume of world production which in 1959 is estimated to have exceed three-quarter million tons, a measure of the importance of titanium oxide is its introduction in the past three to five years into the manufacturing pattern of several industrial economies notably in Europe and British Commonwealth countries, and its inclusion in the development plans of most of the expanding industrial economies in Asia, South America and, of course, in the Communist countries. The new plant projects announced during the past twelve months by the established major producers and several newcomers to the titanium oxide industry appear to meet not only the present needs but also the anticipated increased demand up to 1963 or 1964.

Process

Development work on large-scale refining of various titaniferous raw materials progressed in the late 1920's in Germany, the United Kingdom and the United States. The marketing considerations of the end products narrowed research into two process routes which promised economic operation to compete in the main field of envisaged application, white pigments, which was then dominated by lithopone and white lead. In the U.S.A. the Du Pont Company adopted sulphuric acid as well as chlorine as a means of separating the titanium dioxide from constituent iron and other impurities in the ore. All others, attracted by the abundant supplies and the low cost of sulphuric acid, concentrated their development work on the "Kroll" process in which iron and other deleterious impurities in the ore react with sulphuric acid. This division in technique still persists and, apart from the Du Pont works in the U.S.A. where both the chlorine and sulphate processes are employed, the sulphuric acid route only is being used in all titanium oxide plants throughout the world, including the U.S.S.R., as far as is known.

Notwithstanding great improvements in technique and unit scale—the largest in the world is the 167,000 tons titanium oxide plant of National Lead Co. at Sayreville, N.J.—the process remains operated batch-wise.

Titanium dioxide is manufactured from ilmenite by digestion with sulphuric acid, hydrolysis of the resulting solution, removal of impurities, calcination to develop pigmentary properties, grinding, classifying and, in some cases, coating to impart specific properties. An anatase or rutile variety of titanium dioxide may be produced by certain variations in the operating conditions which determine the physical characteristics of the pigment. Details of the various stages of manufacture are as follows :

Ilmenite Grinding. The ilmenite ore is air-dried and then ground in an air-swept ball mill to a fineness of about 300 mesh. This fine grinding ensures small and constant particle size so that its subsequent digestion with sulphuric acid can be properly controlled.

Digestion. The now finely divided ilmenite and concentrated sulphuric acid are agitated together in large lead-lined and tile-lined reinforced concrete vessels. The temperature of the mixture is raised to 150°C to 180°C until a vigorous reaction occurs. The product of this reaction is a brownish-green friable mass consisting of titanyl sulphate and iron sulphate.

Clarification and Crystallisation. After the process of digestion, the reaction product is dissolved in water and the crude solution then passed to settling tanks for clarification. The solution is freed from all suspended impurities including unreacted ore and colloidal silica, with the aid of flocculating agents such as glue. The liquor is then transferred to evaporators for concentration.

Hydrolysis. The concentrated solution is transferred to precipitating tanks where it is hydrolysed at boiling point. Hydrolysis is a critical process in the manufacture of titanium dioxide for, at this stage, by variation of conditions, the ultimate properties of the pigment are determined. The process is, therefore, subjected to close control.

Filtration and Washing. The precipitated titanium dioxide is concentrated in settling tanks and then thoroughly washed in a battery of rotary filters. This is necessary to ensure the complete removal of all impurities which might otherwise affect the qualities of the final pigment. In addition, the filter cake is treated with conditioning pigments prior to calcination.

Calcination. The washed and purified titanium dioxide in pulp form which comes from the rotary filters is next subjected to heat treatment in a long rotary oil fired calciner. Initially, during its passage through the calciner, moisture and residual traces of sulphuric acid are removed. However, the essential part of the process is the development of the crystalline structure which possesses the optimum pigmentary properties. To this end, conditions inside the calciner are rigorously controlled and continuously monitored.

Grinding and Wet Treatment. The calcined pigment is next subjected to intense milling to break up aggregates. The pigment may then be packed for sale or, alternatively, given further treatment. It has been found that some properties, particularly durability, can be improved by adding specific reagents to a slurry of the pigment in water and subsequently drying the pigment. When such "wet treatment" is used, it is customary to incorporate a wet classification system to separate the fine particles from the coarse, which are then ground further.

RAW MATERIALS

Ilmenite

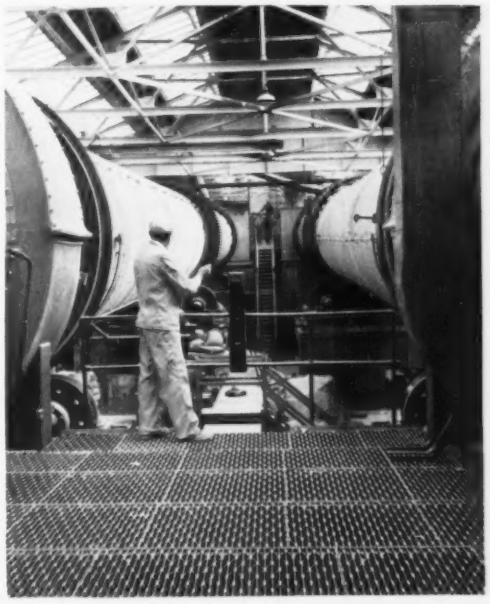
With few exceptions the manufacture of titanium oxide pigments is based on the use of ilmenite, which occurs abundantly throughout the world.

Its most common occurrence is in beach sands, where it is found together with rutile, another titaniferous ore, zircon and often rare earths. The major sources of supply of beach sands are Australia, India, South Africa and large occurrences have also been identified in West Africa and Uruguay. Ilmenite is also found in Norway, Finland, U.S.A.—notably Florida—Mexico and Malaya. The composition of the ore is as follows :—

Titanium Dioxide	45%—60%
Iron (present as oxide)	25%—40%
Alumina	Up to 1%
Silica	Up to 1%

(Lime, magnesia are also present)

Rutile, containing about 95% to 97% TiO_2, is less abundant and, mainly because of



The calcining section of Laporte Titanium Limited's titanium oxide plant at Stallingborough

its higher cost and the increased cost of processing due to the need of its prior fusion with alkali salts before solution can be effected, it is not used in pigment manufacture but confined to titanium metallurgy.

Of mounting importance as raw material in titanium pigments manufacture are the calcines derived from titaniferous magnetite iron ores. There are major deposits in Canada and Norway, and after being smelted in blast furnaces the slag containing up to 70% TiO_2 and only 9% Fe is suitable for digestion in sulphuric acid.

Sulphuric Acid

Because of the varying content of iron and other impurities in ilmenite ores, the quantity of sulphuric acid used in digestion varies between 3 to 4 tons per ton of titanium dioxide pigment. When using titanium slag the appreciably lower iron content reduces acid requirements to 1 to 1½ tons per ton of titanium dioxide pigment. 66° Bé sulphuric acid is used.

It is estimated that current world consumption in TiO_2 manufacture is 2.3 to 2.4 million tonnes of sulphuric acid, representing approximately 5% of total world sulphuric acid use. About one-half of world acid consumption for titanium manufacture is represented by the U.S. industry.

Estimate of Sulphuric Acid Consumption in TiO_2 Manufacture

	1949	1957	1958	1959	1960
U.S.A.	710*	1,130	1,000	1,220	1,200
U.K.	112	319	328	408	450
		'000 tonnes			
Other W. Europe	—	200	220	479	550
Rest of World ...	—	170	190	233	400
Total	822	1,819	1,738	2,340	2,600
Total World Acid Use (Mill. Tonnes)	25.0	43.5	43.0	46.4	48.0

* Incl. all paints pigments uses.

A measure of the decline of the importance of other pigments can be gained from the following comparison of output in the U.S.A. :—

White Lead : **1925**–200,000 t.p.a. **1956**–26,000 t.p.a.
Lithopone : **1929**–200,000 t.p.a. **1958**–30,000 t.p.a.

By far the largest impact made by the titanium oxide industry on the sulphuric acid consumption pattern is in the United Kingdom, where the industry accounts for 16% of total acid use. In the U.S.A. it is estimated to represent 8%, in West European countries producing titanium oxide 5%, and all others less than 2%.

Although sulphuric acid plays an essential part in the manufacturing process, its impact on manufacturing costs is relatively small. This also applies to the cost of ilmenite ore, of which on average 2 to 2½ tons is consumed per ton of pigment ; it is estimated that raw materials costs account for about one-quarter of the posted selling price. Manufacturing costs, however, are substantial in view of high capital investment, labour and fuel costs. In the U.S.A. the ratio between the cost of sulphuric acid used and the posted price of anatase titanium pigment is 1:7¾, while in the U.K. it is 1:7¼. This estimate does not take full account of the value of steam derived from heat recovery of sulphur oxidation and conversion to sulphuric acid. As pigment manufacture requires large quantities of process steam, integrated sulphuric acid manufacture represents a substantial source of heat energy which is credited arbitrarily by different producers, from nothing to the actual fuel value or even the full value of steam.

As yet the application of recovery processes of the sulphur content of the main waste product, copperas, is limited. For every ton of pigment produced from ilmenite about 1¾ tons of iron sulphate arises in the form of heptahydrate ($FeSO_4.7\ H_2O$) which causes a major waste disposal problem. Where recovery is practised it is first reduced to the monohydrate which can then be roasted either alone or preferably enriched with brimstone or pyrites or in conjunction with coal or lignite as reducing agent to recover the sulphate radical as SO_2 which is ready for reconversion to sulphuric acid. British Titan Products Co. Ltd. and Farbenfabriken Bayer AG. employing Dorr FluoSolid and BASF turbulent layer

roasters respectively, have developed efficient processes. The criterion of copperas recovery is as much the saving of the high cost of waste product disposal as the reduction of the net intake of brimstone or other sulphurous raw materials, and thereby the size of the raw materials bill.

PRODUCTION

United States of America

Installed TiO_2 capacity in the U.S.A., the largest producer in the world, is at present 585,000 tons* and is due to reach 630,000 tons by the end of this year.

Production

1938.....58,100	1957...456,600
1947...240,000	1958...404,900
1954...367,000	1959...485,000

With the exception of 1952 when recession substantially cut back demand, the U.S. industry operated virtually to the limit of capacity up to 1956. New construction especially by the Du Pont and American Cyanamid companies reversed the position, and since then there has been substantial surplus capacity. This has been accentuated by exports declining from a peak of 49,000 tons in 1954, due to increasing production activity in Western Europe and more recently in Canada, the largest individual foreign customer of U.S. industry. According to a recent estimate the industry expects to expand its capacity to 800,000 tons by 1965, and over 1 million tons by 1970 of which about 80% is likely to be employed.

E.I. Du Pont de Nemours & Company

Although not wholly relevant to the survey of sulphuric acid use in titanium oxide manufacture, the size of this Company's operations makes its inclusion imperative. For at least 25 years the Company's titanium oxide operations have been based on the sulphate route, but in recent years a substantial part of the output has been derived from processing with chlorine. At present the Company operates titanium oxide plants at Edgemoor, Delaware—55,000 tons per annum, and Baltimore, Maryland—85,000 tons per annum. Both were expanded substantially from 1955 to 1957, but for the time being no further expansion seems to be contemplated. The Company has, however, recently brought on stream a new plant at New Johnsonville, Tennessee, with an annual capacity of 45,000 tons which uses the chlorine route. This new plant raises Du Pont's capacity to 185,000 tons annually.

National Lead Company

The world's largest individual producer, the Company operates a plant at Sayreville, New Jersey, 167,000 tons per annum, and one at St. Louis, Missouri, where production capacity has in the past two years been raised from 83,000 tons per annum to 108,000 tons. The integrated sulphuric acid plants are estimated to have an annual capacity of 1.1 million tons (100% H_2SO_4). They are all contact plants installed by Chemical Construction Company which since the start of the Company's operations has built for it fifteen plants. Since the reconstruction of sulphur discharge and storage facilities at the St. Louis plant in 1954 all sulphur supplies are taken in liquid form, having been brought up stream on the Mississippi from the Frasch domes on the U.S. Gulf.

Glidden Company

During the past three years the Company has been engaged in a major reconstruction of its plant facilities. The old St. Helena plant at Baltimore, Maryland, one of the first commercial units to be established, was dismantled and part of the equipment placed at the disposal of Quimicas Basicas S.A. in Mexico. In its place Glidden Company has built at Baltimore the new Adrian Joyce works with an initial annual capacity of 12,000 tons and which eventually is to be expanded to 60,000 tons. At the Company's second plant at Hawkins Point, Maryland, installed capacity has in the past two years doubled from 24,000 tons to 48,000 tons per annum. All Glidden Company's sulphuric acid requirements are bought in from two major producers in the

* All quantities in this section are in short tons of 2,000 lbs.

area. Titanium oxide materials used include domestic and imported ilmenite and titanium slag.

American Cyanamid Company

At present the Company is the third largest titanium pigment producer in the U.S.A. operating a 18,000 tons per annum plant at Piney River, Virginia, and a plant at Savannah Creek, Georgia. Formerly consisting of one unit of 36,000 tons per annum, a second unit of similar size was completed here early in 1958. The Company produces its sulphuric acid requirements, estimated at 350,000 tons per annum (100% H_2SO_4).

New Jersey Zinc Company

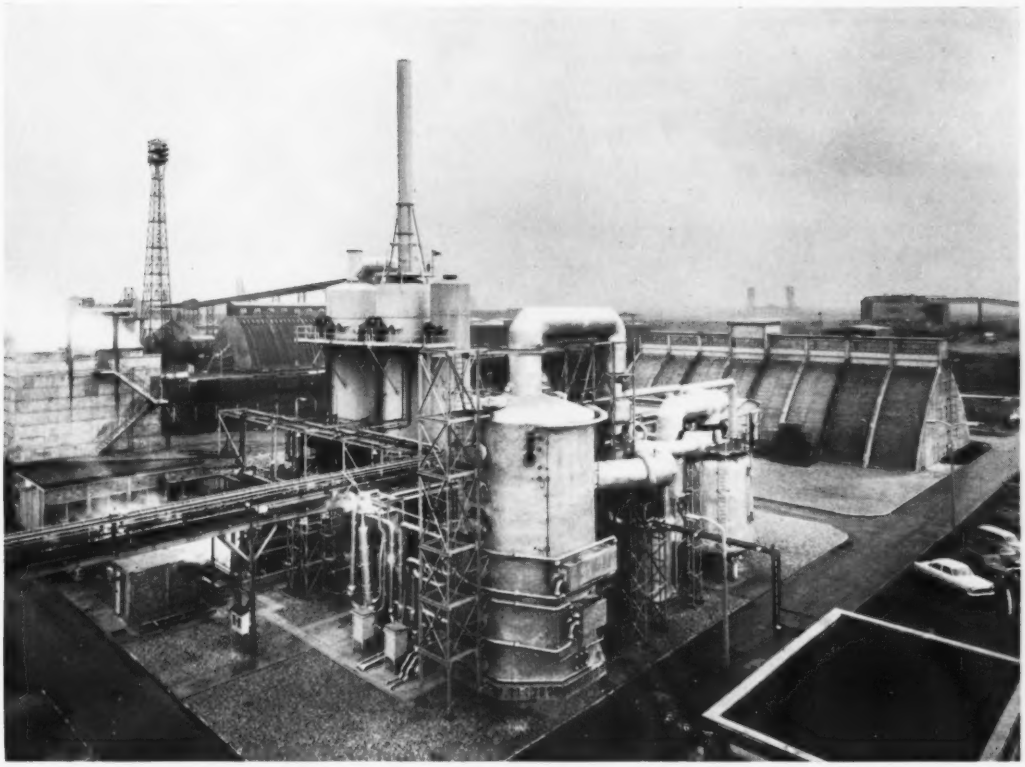
The latest comer to the U.S. titanium pigment industry, this Company entered this industry by purchasing from American Cyanamid Company its plant at Gloucester City, New Jersey, which came on stream under new management on the 1st May, 1956, extending the Company's pigment manufacturing activities which had up to then centred on lithopone production. The installed capacity is 20,000 tons per annum and expansion plans envisage doubling this capacity. The Company produces its own sulphuric acid needs in the form of by-product sulphuric acid derived from SO_2 in zinc smelter gases. Operations are based on the use of titanium slag which the Company obtains from Quebec Iron and Titanium Company in which it holds a one-third interest.

United Kingdom

The titanium oxide industry in the U.K. is the second largest in the world, a position which in the past two years has been strengthened by a vigorous expansion programme. When completed in 1962 the U.K. industry will have installed capacity for the manufacture of 155,000 tons titanium oxide, thereby maintaining its present share of about 12% of world capacity. The impact of this industry's activities on sulphuric acid manufacture has been spectacular both in terms of new plant—eight new installations are solely devoted to meeting its needs—and particularly in the changes wrought in the sulphuric acid consumption pattern. Current consumption of over 400,000 tons (100% H_2SO_4) annually is the second largest single acid outlet, representing 16% of total use and is surpassed only by that of the phosphate fertiliser industry. In addition to meeting mounting domestic requirements, notably of the paint and paper industries, U.K. titanium oxide has established itself in world-wide export markets.

British Titan Products Company

The largest producer of titanium oxide in the U.K. and the third largest in the world, British Titan's share capital of £8 million is owned by Imperial Chemical Industries Limited, Goodlass, Wall & Lead Industries and Imperial Smelting Company (30⅓% each) and R. W. Greeff Limited (9%)—all companies having old-established interests in the paint and pigment industries. At present the two plants of British Titan Products Co. Ltd. have a joint production capacity of 90,000 tons which is shortly to be increased to 105,000 tons. Nearly four-fifths of the Company's output originates at Grimsby where, following last year's completions of plant expansion to 70,000 tons per annum, installed capacity is now being increased by 15,000 tons to 85,000 tons. Over the past three years the Company has substantially increased its sulphuric acid capacity which is now 800 tons per day (100% H_2SO_4) represented by three Chemico plants based on Cyprus and Canadian pyrites concentrates with daily capacities of 140, 160 and 180 tons (100% H_2SO_4), one Chemico brimstone acid plant of 180 tons and one brimstone acid plant of 140 tons built by Simon-Carves Limited. No decision has yet been reached on the means of supplying the acid needs of the latest titanium oxide plant expansion project.



British Titan Products Co. Ltd. General view of the 250 tons per day sulphuric acid plant at Billingham

At Billingham the Company operates a 250 tons per day (100% H_2SO_4) contact acid plant based on brimstone, which when commissioned by Chemico last September enabled British Titan to dispense with acid hitherto bought from the nearby works of Imperial Chemical Industries.

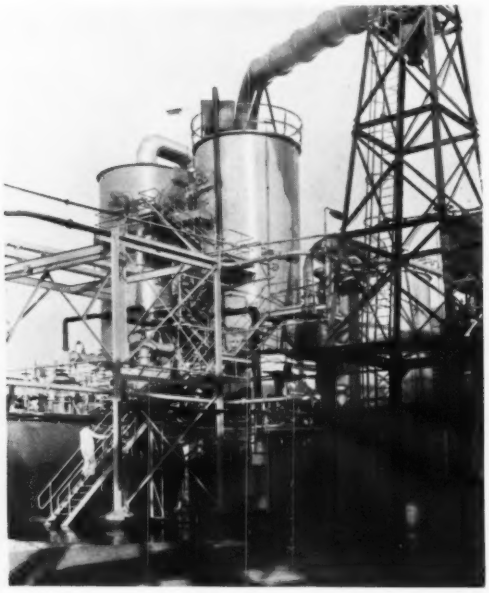
Total production facilities of nearly 1,100 tons per day (100% H_2SO_4) make the Company the largest sulphuric acid manufacturer in the British Commonwealth and among the twelve largest in the world.

As indicated above British Titan Products operate a copperas recovery plant, based on the Company's patented design and process. At present only one of three units of the first ferrous sulphate decomposition plant in the U.K. is in operation and the satisfactory results obtained point to an increase in the level of this activity. The installations comprise spray dryers installed by Kestner Evaporator and Engineering Co. of London, which reduce iron sulphate heptahydrate to the monohydrate, and Dorr FluoSolid reactors originally installed by Chemico to roast pyrites. Coal is used as reducing agent and the unit produces sufficient SO_2 to make about 60 tons per day (100% H_2SO_4) of sulphuric acid, one-third of the plant's capacity.

The expansion project in the U.K. is part of a world-wide expansion scheme which will add a total of 60,000 tons per annum to the capacities of the Company's and its subsidiaries' titanium oxide plants. A substantial proportion of the overall cost of the scheme —£14 million—is to be met from retained profits.

Laporte Titanium Limited

One of the key subsidiaries of the Laporte Industries Group, the Company was the first to manufacture titanium oxide in the U.K. in 1927. Until recently it was known by the name of National Titanium Pigments Limited. At Stallingborough, Lincs., the Company at present operates a 30,000 tons per annum plant which is due to be expanded by the end of 1962 to 50,000 tons. The expansion, which is to involve an investment of £3½ million, is expected to be financed from the Group's own resources. The bulk of the present sulphuric acid needs is met from two integrated contact acid plants. One built in 1953 by Simon-Carves Limited is a flash roaster which has a capacity of 100 tons per day, using principally Cyprus Mines Corporations' flotation concentrates. The other, a brimstone acid plant with a capacity of 175 tons per day was built in 1957 also by Simon-Carves Limited to meet the rising acid needs. The balance of sulphuric acid requirements is supplied by Laporte Acids Limited from plants at Huddersfield and Castleford. The former, consisting of a number of units based on brimstone, pyrites and spent oxide, and incorporating lead chambers as well as a contact convertor, is at present being rebuilt and modernised and will probably operate predominately on brimstone and conversion by the contact process. The plant at Castleford is similar in size and *modus operandi* to the Stallinborough installation. By integrating the group's sulphuric acid facilities present demand is met, but additional sulphuric acid capacity is expected to be installed under the expansion scheme.



Laporte Titanium Ltd. Part of the sulphuric acid plant

Western Germany

Although early development work was pioneered by the Germans, commercial scale production of titanium pigment did not commence until 1956 when Farbenfabriken Bayer AG. in conjunction with National Lead Co. of St. Louis, Mo., established jointly Titan Gesellschaft GmbH. who built a 50,000 tons per annum titanium oxide pigment plant at Uerdingen. A second plant of similar capacity came on stream in 1959. Both plants' sulphuric acid needs are met from Farbenfabriken Bayer's vast acid installations capable of producing over three-quarter million tonnes (100% H_2SO_4) annually, and hitherto based exclusively on pyrites. The net requirements of the titanium oxide plant are minimised by the recovery of the sulphur content in copperas. A 200,000-ton copperas plant is designed, allowing for losses, to yield 53,000 tonnes SO_2 and 55,000 tons of 63% Fe iron oxide. Initially the process was based on the admixture of lignite. Bayer have, during recent months, been using elemental sulphur, thereby augmenting the acid yield. There is also provision for concentrating the dilute acid effluent from the titanium oxide plants.

A further reduction of acid needs is envisaged when a growing proportion of the ilmenite feed is replaced by titanium slag.

Negotiations in this respect are believed to be in progress with Titan A/S of Norway and Canadian slag producers.

In December of last year E.I. Du Pont de Nemours of Wilmington, Del., and Sachtleben AG. of Cologne joined forces and established Pigment Chemie GmbH., in which the German partner will hold 74% of the initial share capital of DM. 35 million (£3 million). The plant, in respect of which Du Pont will provide the technical experience and "know-how", is to be erected at Homberg on the Lower Rhine within the next two years and will have an annual capacity of 18,000 tonnes.

Sachtleben AG., the leading lithopone manufacturer in Germany operates West Germany's largest pyrites mine at Meggen which yields a zinciferous ore. The calcine of this ore contains about 10% to 12% zinc in the form of oxide, and after treatment this concentrated material is used in lithopone production. It is not yet known whether the Homberg plant will purchase acid, of which substantial quantities are available from zinc smelters and from nearby pyrites plants, or whether it will have integrated acid production facilities based on Meggen pyrites.

The new titanium oxide production facilities can be expected to satisfy domestic needs of Germany's large paint, paper and rubber industries, which hitherto, have in part been met by imports.

Holland

A major titanium oxide project has been agreed between N.V. Billiton of The Hague and Albatros Zwavelzuur Fabrieken N.V. of Utrecht. The plant is to be built at Botlek in the newly reconstructed port area of Rotterdam and will have an initial annual capacity of 10,000 tonnes when it comes on stream early in 1962. The Billiton Company's participation is 55% and that of Albatros 45%. Technical "know-how" is to be supplied by the Glidden Company of Baltimore, Maryland, and investment is envisaged to total D.Fl. 30 million (£2¾ million) of which D.Fl. 25 million will be devoted to the new plant, the rest as working capital. Sulphuric acid supplies will originate from the new sulphuric acid plant now under construction at Pernis, as a joint enterprise of Albatros Superfosfaatfabrieken N.V., Holland's leading phosphate fertiliser manufacturer, and Cyprus Mines Corporation. Based on pyrites concentrates, the plant is to embody the latest techniques of heat recovery to ensure that sulphuric acid is produced at the lowest possible cost and capable of competing in an area where Europe's cheapest sulphuric acid is available most plentifully.

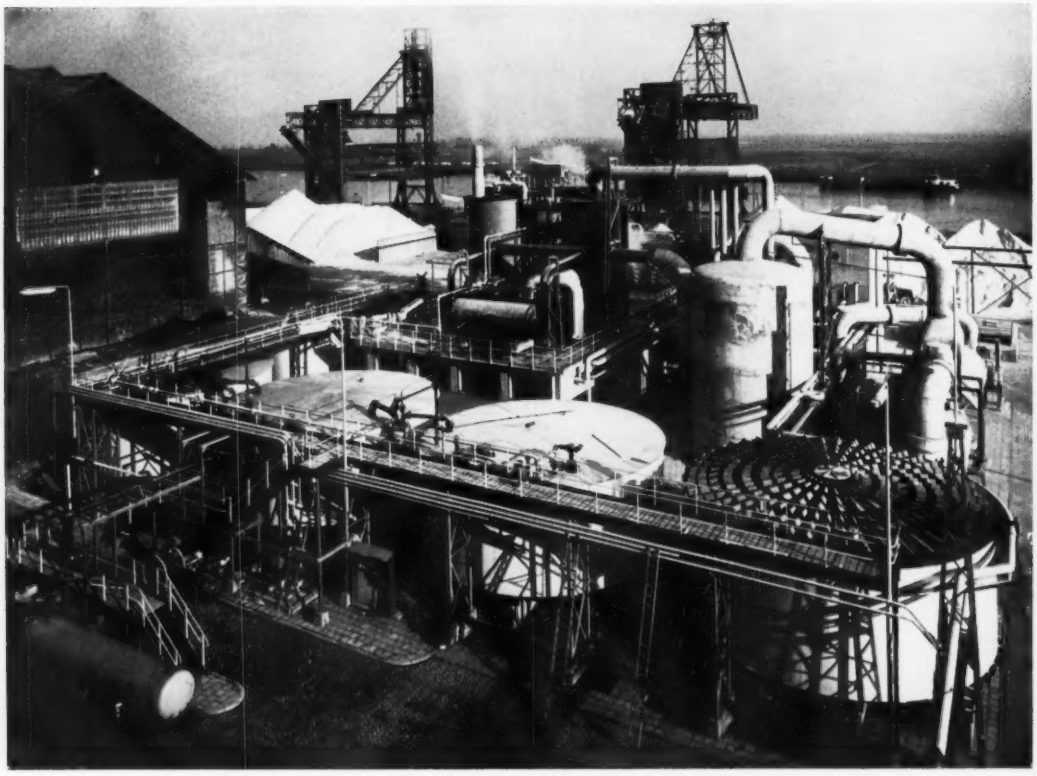
France

Installed production capacity is at present 25,000 tonnes per annum titanium oxide. Produits Chimiques de Thann et Mulhouse at Strasbourg is an old-established manufacturer whose installed capacity of 10,000 tonnes per annum has not been adequate to meet growing French pigment needs. The plant is integrated with the Company's substantial sulphuric acid facilities which are based on brimstone and indigenous pyrites.

In 1958 to fulfil evident demand Cie. St. Gobain in co-operation with the National Lead Co. established Le Titane S.A., to produce titanium oxide at Le Havre. The plant with an annual capacity of 15,000 tonnes obtains its sulphuric acid needs from the nearby works of Cie. St. Gobain which has a daily capacity of 240 tonnes (100% H_2SO_4) based on brimstone and H_2S. The latter is recovered at the adjacent oil refinery.

Belgium

Established as recently as 1957, Société Chimique des Derivés du Titane is owned by Belgian interests and National Lead Co. of St. Louis, Mo., which has a majority holding in the Company. Believed to have an annual production capacity of 10,000 tonnes titanium oxide, manufacture is based on the use of



General view of 150-tons-per-day brimstone burning plant of N.V. Nieuwe Nederlandsche Maatschappij Spiegelglas at Sas van Gent. About 20% of the company's acid production is sent to Soc. Chimique des Derivés du Titane

Canadian titanium slag while sulphuric acid requirements are bought in primarily from the nearby works of N.V. Nieuwe Nederlandsche Maatschappij tot vervaardigen van Spiegelglas at Sas van Gent and also from members of the Asybel Group. At Sas van Gent sulphuric acid manufacture is based on a 40 tonnes per day pyrites acid plant and a new 150 tonnes brimstone acid plant built by Werkspoor N.V. in 1958 ; the other suppliers derive their acid supplies predominately as a by-product from zinc smelter gases.

Italy

Titanium oxide has been manufactured for a number of years by Soc. Montecatini as an essential product of the Company's comprehensive range of pigment materials. The Company's first plant at Bovisa (Milan) which had an annual capacity of 6,000 tonnes was extended to 9,000 tonnes in 1954. A new plant came on stream in 1955 and its present capacity following an expansion in 1957, located at Spinetta Marengo, is believed to be also 9,000 tonnes. The plants' sulphuric acid needs are supplied from Soc. Montecatini's own resources which are based on pyrites.

Spain

Built in the late 1940's the titanium oxide plant of Union Quimica del Norte de España S.A., Bilbao, with an annual capacity of about 7,000 tonnes, is still the only producer in

Spain. It is part of a wide range of chemicals manufacturing facilities which include a pyrites based sulphuric acid installation.

Finland

Construction started in 1959 of an important titanium oxide project. The plant with an annual capacity of 16,000 tonnes of primary rutile — quality titanium oxide, is being built by Vuorikemia Oy, is likely to come on stream this year. Ilmenite requirements are to be met from local deposits, while its sulphuric acid needs will be met from a new 50,000 tonnes per annum contact acid plant being built nearby by Rikkihappo ja Superfosfaattitehtaat Oy. By-product smelter gas from the copper smelter of Outokumpu Oy is supplying the sulphur requirements. A feature of the operations is the envisaged storage of the copperas in crystal form with a view to recovery at a later date. Despite every endeavour made to ensure low cost operations, it is unlikely that Finnish titanium oxide will be competitive with imports, a large proportion of which has come from the United Kingdom. The Finnish Government is understood to have assurred the enterprise of some financial assistance, probably in the form of capital and tax facilities to ensure its success. Apart from the mounting Finnish titanium oxide consumption, notably in the paper industry, this new industry helps to diversify further the struggling Finnish economy.

Canada

One of the world's largest markets mainly on account of its paper industry, Canada remains the principal export outlet for the U.S. titanium oxide industry, and is also an important market for the U.K., notably British Titan Products Co. Ltd. which quadrupled its sales between 1950 and 1957 when the Company accounted for one-half of total titanium dioxide sales in this country. The first domestic plant was built in 1956 when Canadian Titanium Pigments Limited, a subsidiary of National Lead Co. of St. Louis, Mo., projected a 18,000 tonnes per annum installation at Varennes, Quebec, on the South Bank of the St. Lawrence River. Based on titanium slag its sulphuric acid needs are modest. There is an integrated sulphuric acid plant with an annual capacity of 50,000 tons (100% H_2SO_4) based on brimstone. Although the plant was the first in Canada to use Mexican Frasch sulphur, its main supplies continue to be bought from U.S. Frasch mines. Under the world-wide expansion scheme of British Titan Products, a plant, the largest individual project, is to be built at Sorel, Quebec. It will produce both anatase and rutile types of titanium dioxide at an annual capacity of 20,000 tons, involving capital expenditure of £6 million. The design will facilitate considerable expansion at a later date. It will have an integrated sulphuric acid plant based on brimstone.

Australia

Manufacture of titanium oxide is confined to the operations of Australian Titan Products Company Limited, a subsidiary of British Titan Products. The works at Burnie, Tasmania, have an annual capacity of 8,000 tons which under British Titan's Commonwealth expansion scheme is being raised to 10,000 tons by the end of this year. By early 1962 output is to be raised to 16,000 tons per annum and by mid-1963 to 22,000 tons. The plant's sulphuric acid needs are wholly met by the purchase of by-product sulphuric acid

Soc. Montecatini. General view of the titanium oxide plant at Spinetta Marengo

from the Electrolytic Zinc Co. of Australasia's installations at Risdon, Tasmania, where total installed capacity is 175,000 tons per annum (100% H_2SO_4) wholly based on sulphur dioxide in the exit gases of the zinc concentrates roaster.

India

Travancore Titanium Products Limited has been producing titanium pigment for some years in a plant with a capacity of 1,800 tons per annum which is currently being expanded to 3,600 tons annually. Chemiebau Dr. Zieren of Cologne is building a contact acid plant with an annual capacity of 16,500 tons (100% H_2SO_4) based on imported brimstone, and this is due to come on stream early this year. In view of the rapid growth of industrial activity in India a further increase of titanium oxide capacity is expected. When this happens, the possibility of other producers entering this growing market cannot be excluded.

Union of South Africa

Stimulated by the existence of large reserves of titaniferous raw materials, a project for indigenous manufacture of titanium pigments was initiated in 1956. African Explosives & Chemical Industries Limited and British Titan Products Company Limited in a joint venture, in which the former has a 40% interest, will build a 10,000 tons per annum plant at Umbogintwini. The manufacturing requirements of steam and sulphuric acid are to be met by A.E. & C.I.'s established facilities at Umbogintwini, where annual installed sulphuric acid capacity wholly based on brimstone is 251,000 tons (100% H_2SO_4) in the form of a 93,000-ton contact plant, 22,000-ton lead chambers and a 136,000-ton Peterson tower plant. The titanium oxide project due to be completed in 1962 forms part of British Titan Products' recent expansion scheme.

Mexico

The country's rapidly expanding needs, coupled with the Government's desire to diversify the pattern of industry, prompted in 1958 two major U.S. producers, hitherto exporters of titanium pigments to Mexico, to consider establishing subsidiary production facilities. Du Pont actually formed a subsidiary and initiated a 8,000 tons per annum project on which construction started. Simultaneously the Glidden Company, co-operating with the State banking enterprise Nacional Financiera S.A. agreed to provide to Quimicas Basicas de Mexico S.A., know-how and equipment partly from its redundant St. Helena plant at Baltimore, Md. for a plant of similar size. The installation was to include a 100 tons per day sulphuric acid plant. Since existing demand was in the region of only 5,000 to 6,000 tons per annum of titanium oxide, the joint capacity of the two projects by far exceeded practicable outlets and in 1959 both projects came to a halt, while appeals to the Government for a measure of protection and exclusivity received consideration. It is not known whether there has been a clear-cut decision, but Du Pont's subsidiary Pigmentos y Productos Quimicos S.A. de C.V. resumed construction in August, 1959, and the plant is due to start up in April of this year. Sulphuric acid needs will be met from an integrated brimstone acid contact plant. This, a Monsanto-type 60 tons per day (100% H_2SO_4) sulphuric acid unit, is being built by Simon-Carves Ltd. of Cheadle Heath, Cheshire.

Brazil

The production facilities of Cia Quimica Industrial C.I.L., S.A. of Sao Paulo, which are capable of producing annually 3,000 tons titanium oxide are being doubled ; expansion is to be completed this year. The Company also produces barium sulphates. It operates two sulphuric acid plants, an old 10 tons per day Leonard/Monsanto unit and a 50 tons Conpan/Monsanto plant built in 1958. Both are based on imported brimstone.

Japan

Titanium oxide manufacture holds an important place in Japan's chemical industry.

Installed capacity in 1958, represented by seven producers, was about 45,000 tons per annum. The largest producer is Ishihara Sangyo Kaisha K.K., whose plant at Yokkaichi, Mei Prefecture, has an annual capacity of 24,000 tons. Both rutile and anatase types of pigment are produced and manufacture is based on ilmenite from Western Australia and increasingly on titanium slag from Canada. Consequently, copperas disposal does not present a major problem. Waste acid is utilised by the Company for gypsum manufacture. The other producers are as follows :—

Producers	Location	Capacity t.p.a.
Titanium Industry Ltd.	Ube, Yamaguchi-ken	3,600
Tochigi Chemicals Industry Ltd.	Tokyo	6,000
Teikoku Chemicals Industry Ltd.	Osaka	5,400
Furukawa Industry Ltd.	Osaka	3,600
Sakai Chemicals Industry Ltd.	Osaka	1,800
Mitsui Chemicals Industry Ltd.		240

These manufacturers use predominately ilmenite and the by-product copperas is sold as red pigment. Sulphuric acid needs are currently estimated at 110,000 to 120,000 tons annually, and they account for two-thirds of the requirements for inorganic chemicals manufacture other than fertilisers. Approximately half the titanium dioxide output is consumed domestically and the balance is exported. No immediate expansion of titanium capacity appears to be contemplated. A project for 3,600 tons per annum titanium oxide by the Nisso Steel Manufacturing Company, which is believed to produce titanium slag from some of its blast furnace operations, has not been advanced beyond the preliminary stage.

U.S.S.R.

Titanium oxide appears to have been produced on a relatively modest scale for several years. In 1959 it was said that within the framework of the greater manufacturing effort for consumer goods, titanium oxide is to be substantially increased and plant construction licences were obtained from France and Japan.

China

Small-scale production is reported and it must be expected that in common with other chemicals manufacture the number of plants and their capacity are being increased rapidly.

Czechoslovakia

As an adjunct to its established pigment industry, a 3,000 tons per annum titanium oxide plant has been in operation for some years. Recent plans provide for a major expansion by the construction of a new plant which will raise the country's annual capacity to 20,000 tons. As existing sulphuric acid facilities are fully extended, it is expected that the new project will include the construction of an integrated sulphuric acid plant. In anticipation of Polish supplies being available next year, this is likely to be based on brimstone, an assumption strengthened by the trend of recent brimstone purchases from the West.

Conclusion

The outstanding pigmentation properties of titanium oxide, which impart exceptional opacity, coupled with its relatively low cost, inertness and non-toxic qualities have assured its superiority over the various metallic oxide pigments. Its use in the manufacture of paint and paper holds the key to the world-wide growth of this industry. Moreover, a number of lesser consuming industries have also found in titanium oxide a valuable raw material. The current U.S. pattern of titanium oxide consumption provides a useful yardstick.

Paint, Varnish and Lacquer	58%	Rubber ...	5%
Paper	14%	Coated Textiles	4%
Floor Covering	5%	Printing Ink ...	2%
		Miscellaneous ...	12%

Of several new uses of titanium oxide two promise substantial growth : incorporated in proofing materials it imparts heat resistance and used as a curing aid for concrete especially

in road construction in hot climate the addition of titanium oxide helps to control the rate of setting.

In the past ten years world consumption of titanium oxide has trebled, and despite the current world-wide expansion of demand and plant capacity, a more modest rate of growth must be expected for the next decade.

In the U.S.A. installed plant capacity has been under-employed for at least two years and whereas demand elsewhere especially in W. Europe and the United Kingdom has caused existing plants to be working intensively, the recently announced actual and planned additions to plant capacity notably in the United Kingdom and the construction of new plants in W. Europe and Commonwealth countries indicate that adequate provision has been made to allow for the anticipated growth in titanium oxide demand in the next three to four years.

Outside Communist countries, world consumption is likely to rise at an annual rate of 10% to 12% from the present level of ¾ million tons to reach over 1½ million tons by 1970. In the same period the rapid expansion of chemicals manufacture in the U.S.S.R. and China and the emphasis in Eastern Europe and U.S.S.R. on consumer goods could result in planned production of ½ million tons annually and probably more.

Of the two main titanium oxide pigment types, consumption tends to focus more on the rutile variety. In the U.S.A. and the U.K. output and use appear to have been established at 75% rutile and 25% anatase types. In Europe and the Commonwealth this trend appears to be followed, despite the more complex manufacturing process of the rutile grade. The differences of opinion on the merits of titanium oxide pigment produced by the chlorine or sulphuric acid routes continue unabated and inconclusively. Recently, in the U.S.A. it centred on a claim by Du Pont that chlorine type pigment was more readily adaptable to water-based paints, but this was promptly rejected by the other producers. Unchallenged in the industry are perhaps only National Lead's calcium sulphate extended pigments for which the company expects substantial growth.

The current rate of production of titanium oxide is estimated to require about 2.4 millon tons sulphuric acid, the manufacture of which appears to be based on the use of 436,000 tons Frasch sulphur, 100,000 tons recovered sulphur, 650,000 tons pyrites and 60,000 tons sulphur in zinc smelter gases and recovered from copperas, a total of approximately 825,000 tons sulphur in all forms. Growth of world consumption of titanium oxide—excluding Communist countries—is expected to result in net additional sulphur needs of about 130,000 tons in 1961. By 1965 it is estimated that world consumption of sulphur for this purpose will have risen to about 1.2 million tons, while by 1970 the titanium oxide industry is likely to call on 1.4 million tons sulphur. The expectation of lesser rate of expansion in sulphur use than of titanium oxide is thought to be justified because of the likely increase in copperas recovery and the increased use of titanium slag resulting in lower net requirement of sulphuric acid. Also the possibility that plants other than Du Pont's in the U.S.A. may adopt the chlorine route of manufacture cannot be excluded. Recent technical advances in economic methods of chlorine recovery from dilute acid could make this form of chemical energy increasingly attractive in the titanium oxide industry. Notwithstanding such developments, titanium manufacture promises to remain one of the major outlets for world sulphur supply at an annual rate, if Communist countries are included, of nearly 2 million tons sulphur by 1970. It is also evident that despite the relatively modest impact of the cost of sulphuric acid on the cost of the end product, at present only 12% to 14%, the need for low cost sulphur remains imperative if the titanium oxide industry is to continue relying predominately on sulphur in an essential process step.

Grand Isle Offshore mine. From left to right—Power plant, living quarters, heliport, production platform and bleedwater unit. In the foreground the second of the two mammoth deck sections for the power plant is being lifted by an 800 ton crane. Each section weighs 645 tons

Freeport's Grand Isle Sulphur Dome on Stream

ON 14th April Freeport Sulphur Co.'s Grand Isle sulphur dome came on stream. The world's first off-shore sulphur plant Grand Isle will eventually cost approximately $30 million of which $8 million represents the extra cost (over a shore installation) for building seven miles off the Louisiana coast in the Gulf of Mexico.

Sulphur rights at Grand Isle were acquired by Freeport from Humble Oil in 1956. The contract stipulated that building of the plant was to begin in 1958 and that production should begin in 1960. It also gives Humble 50% of the net profits from the operation, with provisions for Freeport to amortise their capital investment.

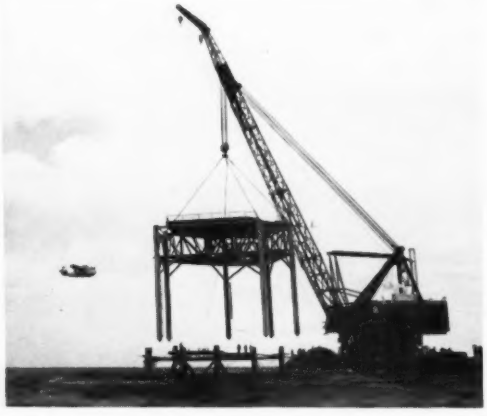
Contrary to industry's belief that Freeport would have to work Grand Isle to full capacity to make it pay, even at the cost of cutting back production at their other plants, the company contends that this plant's production will be based on market conditions—that is sulphur demand and inventory needs. Freeport also consider that this off-shore deposit will eventually become one of the world's lowest cost producers because the plant will be an economic one to operate; the plant is highly automated, and requires fewer personnel than a similar land-based plant. The waste water system, for instance, built on a separate 'island' off the whole Y-shaped steel structure needs no men to work it, except for maintenance. Indeed, Freeport go so far as to say that sulphur mined at Grand Island will cost the company no more than its other sulphur production and eventually may cost less.

Freeport also consider that Grand Isle will give them a dominant position in sulphur reserves. At present the estimated reserves of the dome are not revealed although the company has indicated that it is the third largest sulphur deposit in the United States, Texas Gulf Sulphur's Boling Dome in Texas and Freeport's Grand Ecaille being larger.

The Grand Isle Deposit

The sulphur deposit was discovered in 1949 when Humble Oil and Refining Co. penetrated over 200 ft. of sulphur-bearing limestone between 1813 and 2075 ft. while drilling their No.1-B oil prospect. In 1945, Humble drilled 10 sulphur prospect holes, eight of which encountered sulphur ore. The ore body embraces several hundred acres and its outer limits have yet to be defined to the north-east, east and south. One well, about 2,600 ft. north east from the nearest commercial well, cut 75 ft. of low grade sulphur-bearing rock at 7495 ft., the deepest occurrence of elemental sulphur yet encountered in the Gulf Coast area.

Depth of the Grand Isle orebody ranges from 1,800 ft. to 2,500 ft. Within the present boundary the sulphur-bearing limestone varies in thickness from 220 ft. to 450 ft. while the sulphur content varies from an average of about 15% in the leanest hole to an average of about 30% in the richest. Although the sulphur enrichment is stated not to be particularly high, the thickness of the orebody is substantially greater than other Gulf Coast deposits.



Setting deck section on piles driven through and cut off just above template legs

The sulphur occurs in crystalline masses, in vugs, in disconnected veinlets, and as disseminations throughout the rock. Traces of oil occur, so it is expected that the sulphur produced from this mine will be discoloured. Anhydrite underlies the sulphur horizon and varies from 29 ft. to 190 ft. in thickness, and has the typical saccharoidal texture found in Gulf Coast salt domes.

Production Possibilities

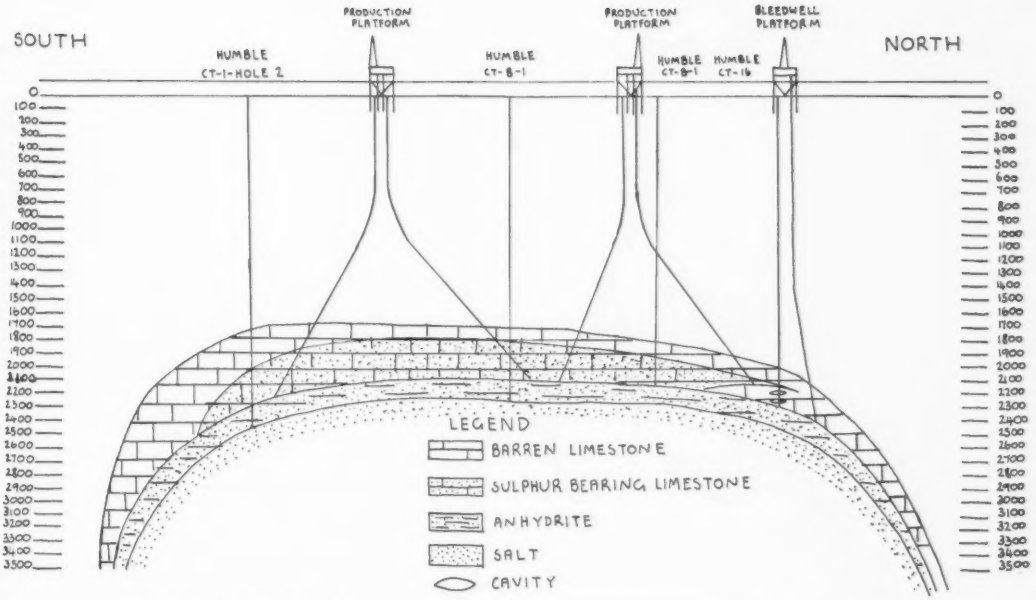
Mining is by the Frasch process which requires simultaneous heating of several wells by injecting water heated under pressure to about 325°F. The liquified sulphur collects at the bottom of the well and is reclaimed by air-lift pumping.

Production capacity at Grand Isle will not be known until Freeport have gained some operating experience. The heating plant, however, has been designed to deliver an average of 5 million gallons a day of water at 325°F with a peak in excess of 5.5 million gallons daily. If the mine has a low 'water-ratio', as Freeport expects, then Grand Isle could produce from 2,500 to 3,300 tons a day of sulphur (based on a water ratio of 1,500 to 2,000 gallons a ton). This would make it one of the companies top producers (Grand Ecaille's output has before now averaged 5,500 tons a day over a period).

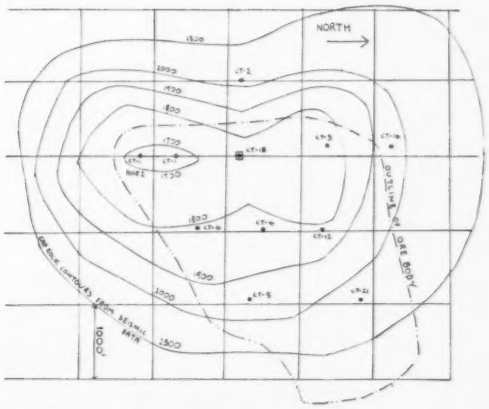
Structural Design Features

Basic facilities for the Frasch process are the same whether onshore or in the Gulf, but major design problems have made Grand Isle unique.

- The 50 ft. water depth at the mine location and the extremes of weather in the Gulf impose special problems in the design and construction of foundations
- Historically, the Frasch industry has been dependent on fresh water in large quantity but as the nearest source of fresh water—



Above : North-south section through dome. Right : Location of Humble's prospect holes, etc.



the Mississippi River—is 25 miles away, this need had to be overcome.

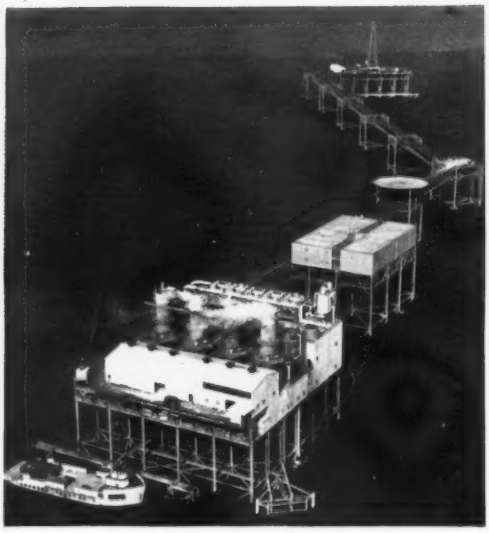
- A safe reliable, all-weather system was required to get the sulphur inshore for storage.

To mine the dome, men will be working on the world's largest steel island, a giant 'Y'. Major units of the installation are set on steel-pile supported platforms raised 75 ft. and 60 ft. respectively above the water and connected by a series of 200 ft. long bridges. The clearance is needed as the island must be able to withstand not only line squalls of 50-90 m.p.h. but also hurricane winds of over 100 m.p.h. that can generate waves up to 45 ft. high. In view of the hurricanes the plant can be shut down in about an hour and restarted in about four hours with the aid of a 1,000 H.P. Clarke TA gas turbine which drives an 800 k.W. Elliott generator.

On one platform, the steam-generating plant, warehouse and workshops are housed; another platform holds the offices and living quarters, and a heliport is located on a small platform nearest the living quarters. From this last steel bridges 200 ft. long branch out to two directional drilling platforms (to date only one is complete). Each platform is designed with openings to drill from 36 surface locations.

Subsidence

After depletion of the deposit calculations indicate that vertical surface subsidence of 43 ft. to 45 ft. will have taken place at the



Aerial view of platform. Power plant in foreground

centre of the ore body. The living quarters are expected to settle five feet and the heating plant about three feet, while subsidence at the first two production platform locations is expected to be about 25 ft.

Provision already exists for extending the tubular supports to counteract initial settlement of up to 10 ft.

The production platforms are not permanent; they will be salvaged and reconstructed at their original elevations after the main settlement has occurred.

Corrosion Problems

Corrosion of steel of which the island is composed presents a constant problem. Cathodic protection is used to protect totally submerged pilings and a diver will be on constant call to inspect the graphite anodes and make any changes required. Heavy steel plate ($\frac{1}{4}$ in. structural plate containing 0.2% copper) has been used for the alternately wet and dry splash zones. As sulphur is withdrawn from the dome and the structure settles, the thicker sections will eventually sink into the cathodically protected zone.

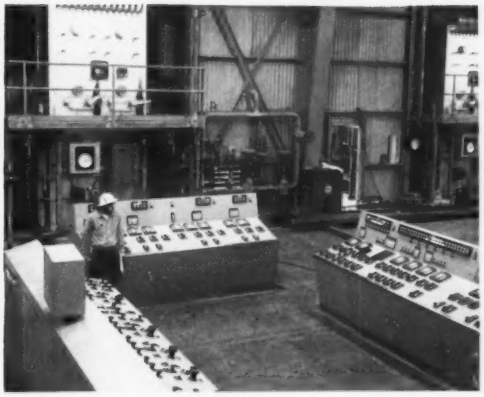
Dumetcote, an inorganic zinc silicate coating supplied by Amercoat Corporation has been applied in both splash and salt air zones, at an estimated cost of over $1 million (50 cents/sq. ft.). Once a year an eight-man team will be called upon for about one month's work in recoating corroded areas.

Potential corrosion of contacts was considered a hazard of the electronic systems, so instruments are pneumatically controlled, and to overcome problems of corrosion to aluminium and high temperature melting of plastics, air lines are of copper.

Heating Plant

Grand Isle's heating plant, which is the world's third largest Frasch plant, is designed to deliver an average of 5 million gallons of 325°F water per day with a peak load in excess of 5.5 million gallons a day. It will burn on an average 13 million cubic feet of natural gas daily and will produce 360,000 lb. steam per hour at 600 p.s.i.g. and 600°F, generate 4,500 k.W. at 2,400 volts and compress 2,500 c.f.m. of air to 1,000 p.s.i.g. Plant efficiency at full load is expected to be 93.5%, a 6.5% loss being attributed to radiation, and stack losses. (For details of major equipment, see page 21).

Lack of fresh water is no problem. The heating plant has been designed to operate on water of any salinity for Freeport have spent eight years of research on the problems of salt water heating, which has been in operation at Bay Ste. Elaine from 1952 until the plant was shut down last year (see page —). Seawater at 75°F is sprayed into the top of preheater towers and percolates downward through two beds of ceramic rings — the upper bed raises water temperature to 140°F by contacting upward flowing stack gases from the boilers. The lower bed raises temperature to 190°F with heat from six air-gas premix burners, then high-pressure centrifugal pumps pick up the water and force it through 20 heat exchangers to complete the heating process. It



A portion of the control console in the offshore power plant

leaves the exchangers at 325°F and 400 p.s.i.g. —enough pressure to force it into the wells.

Directional Drilling

At Grand Isle the wells will be directionally drilled from the multi-well platform so that wellheads can be concentrated in a small area while the bottom hole locations can be widely scattered. Freeport, of course, have been directionally drilling since 1944, but at Grand Isle they believe that they are drilling at sharper angles to the vertical than is done elsewhere. The wells have a vertical depth of about 2,200 ft. and the end is as much as 1,250 ft. to one side of the drilling platform.

The drilling platform has openings to drill from 36 surface locations on 11 ft. centres. Not more than 12, however, will be used at one time. After a producing well has been depleted of sulphur, the pipe will be salvaged and the bottom portion of the well will be plugged and abandoned. The same conductor pipe and surface casing will be re-used.

Each of the 36 surface locations will be used about three times and thus 108 wells will be drilled from each platform. Bottom hole spacing will be about 175 ft.

Offshore the control station is situated on the same platform as wellheads. Takeoffs for each well incorporate water-metering and control equipment.

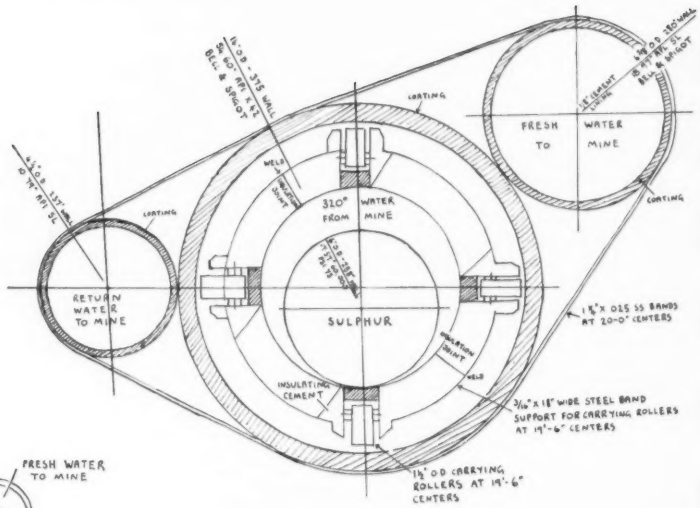
Underwater Pipeline

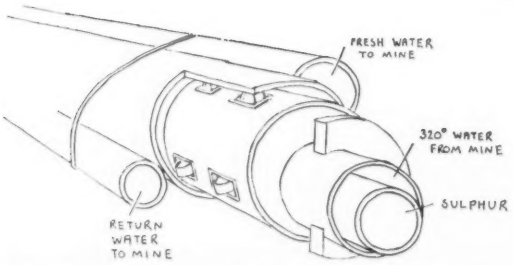
Studies indicated that the most economical, reliable, all-weather means of getting the sulphur to Port Sulphur was by pipeline from the mine to Grand Isle, Louisiana, and by liquid barges from Grand Isle to Port Sulphur. (The original intention of transporting liquid sulphur direct from the offshore mine to Port Sulphur by barge has been abandoned).

Sulphur will be piped into two 40-ton collecting tanks, then into the seven-mile underwater pipeline, itself an engineering masterpiece. This pipeline, buried about 5 ft. below the Gulf floor contains three concentric pipes: a 14 in. O.D. protective casing, a 7⅝ in. O.D. hot water jacket line, and a 6 in. O.D. sulphur line. Maximum capacity of the pipeline will be 4,500 long tons of sulphur a day. Sulphur enters the pipe at 320°F, but drops to 280°F by the time it reaches the shore. Heat loss is described as 'modest' as the result of insulation and air-gap in the pipeline. This loss, it is

Scale model of directional drilling platform. Each rod is a well; many wells will be worked over and re-completed

Right: Cross section of offshore sulphur line at rollers. Below : Cut-away perspective of off-shore sulphur line


FRESH WATER TO MINE
COATING
310° WATER FROM MINE
RETURN WATER TO MINE
SULPHUR
INSULATING CEMENT
WELD
1⅛" X 018 SS BANDS AT 20-0" CENTERS
3/16" X 18" WIDE STEEL BAND SUPPORT FOR CARRYING ROLLERS AT 19'-6" CENTERS
1½" O.D. CARRYING ROLLERS AT 19'-6" CENTERS



estimated, may reach 75 million B.Th.U. a day, (equal to about $20 a day).

Two additional pipelines are set alongside the main pipeline. One returns spent heating water to the mine and the other provides a limited source of fresh water for the plant. Since this water will not be deaerated the dissolved oxygen will make it slightly corrosive and for this reason the line is protected inside by a coating of cement.

Pipeline Movement Prohibited

A unique feature of the pipeline is stated to be the method of overcoming the thermal stresses. Expansion joints have therefore been eliminated, and by anchoring the pipeline movement is prohibited. Because of the stress the anchoring imposes on the pipeline the inner pipelines are constructed of a high tensile steel having a yield strength of about 60,000 p.s.i.

Before being buried the outer casing was placed in 10,000 p.s.i. tension by exerting a pull on each end. The ends have been fixed temporarily to an anchor structure while still in tension, but as the soil becomes remoulded around the pipeline, soil resistance will be sufficient to prevent appreciable movement.

Molten sulphur is transferred at the Louisiana coast to barges which carry the sulphur 25 miles to Port Sulphur, Freeport's storage and loading terminal at the Mississippi River. The loading installation at Grand Isle incorporates a hydraulic ramp which automatically adjusts to the level of the barge.

Personnel

About 175 men will be required to operate the mine and sulphur transport system. Of these 150 will operate the mine, but only half will be stationed at the mine at any one time. The mine will operate 24 hours a day, seven days a week, excepting emergency shutdowns due to storms and hurricanes. The men will work five consecutive 12-hour days living at the mine, then they will be on leave for five days. Helicopters will transport the working personnel to the mine.

Design, Engineering, etc.

Freeport's engineering staff have been responsible for the design, engineering and construction of the Grand Isle mine; to

augment the department the following were called upon for assistance :

Bedell and Nelson Engineers Inc.—detailed engineering design of structures and power plant facilities.

A. H. Glenn Associates—wind and wave forces, and design criteria for offshore structures.

Eustis Engineering Co.—test borings and pile load determinations.

Brown and Root Engineers Inc.—structural reviews of offshore platforms and feasibility studies for offshore sulphur mine.

Brown & Root Marine Constructors and J. Ray McDermott Co.—General construction advice and review of offshore construction aspects in relation to ' lift ' sizes and onshore fabrication.

Sargent and Lundy—overall review of the power plant design.

Texas A. & M. Research Foundation—oceanographic studies for sulphur pipeline.

Moran Towing and Transportation Co.—overall study of offshore sulphur transportation.

Heating Plant Equipment.

4 Riley Type RX15 pressure furnaces 90,000 lb./hour 600 p.s.i.—600°F gas-fired waterwall boiler with turbine-driven induced draught fans.

4 mine-water preheater packed towers with 6–7 mm. B.Th.U. asperating gas burners and turbine driven forced-draught fans.

3 Worthington 1,500 k.W. turbo generators and excitors at 150 p.s.i. exhaust and 190 p.s.i. uncontrolled extraction for boiler feed heating.

1 Clark T.A. gas turbine 800 k.W. generator and excitor self-contained.

1 Allis-Chambers 300 k.W. self-contained diesel generator.

3 Clark C.M.A.$_4$ 830 c.f.m. 1,000 p.s.i. motor driven air compressors and excitors.

4 Pomona deep-well pumps — 3 turbine drive, 1 diesel drive.

1 Lane deep-well pump with Pfleuger submersible motor.

2 Infilco 26 ft. diam. water softeners.

20 Tubular heat exchangers for mine water.

2 Griscom-Russell cupro-nickel single-stage sea-water flash evaporators.

4 Byron Jackson Alloy 20, 1,400 g.p.m., 500 p.s.i., turbine-driven, mine-water pumps.

21 Other turbine-driven pumps, chemical injection system, boiler feed tanks, heat exchangers and other auxiliaries.

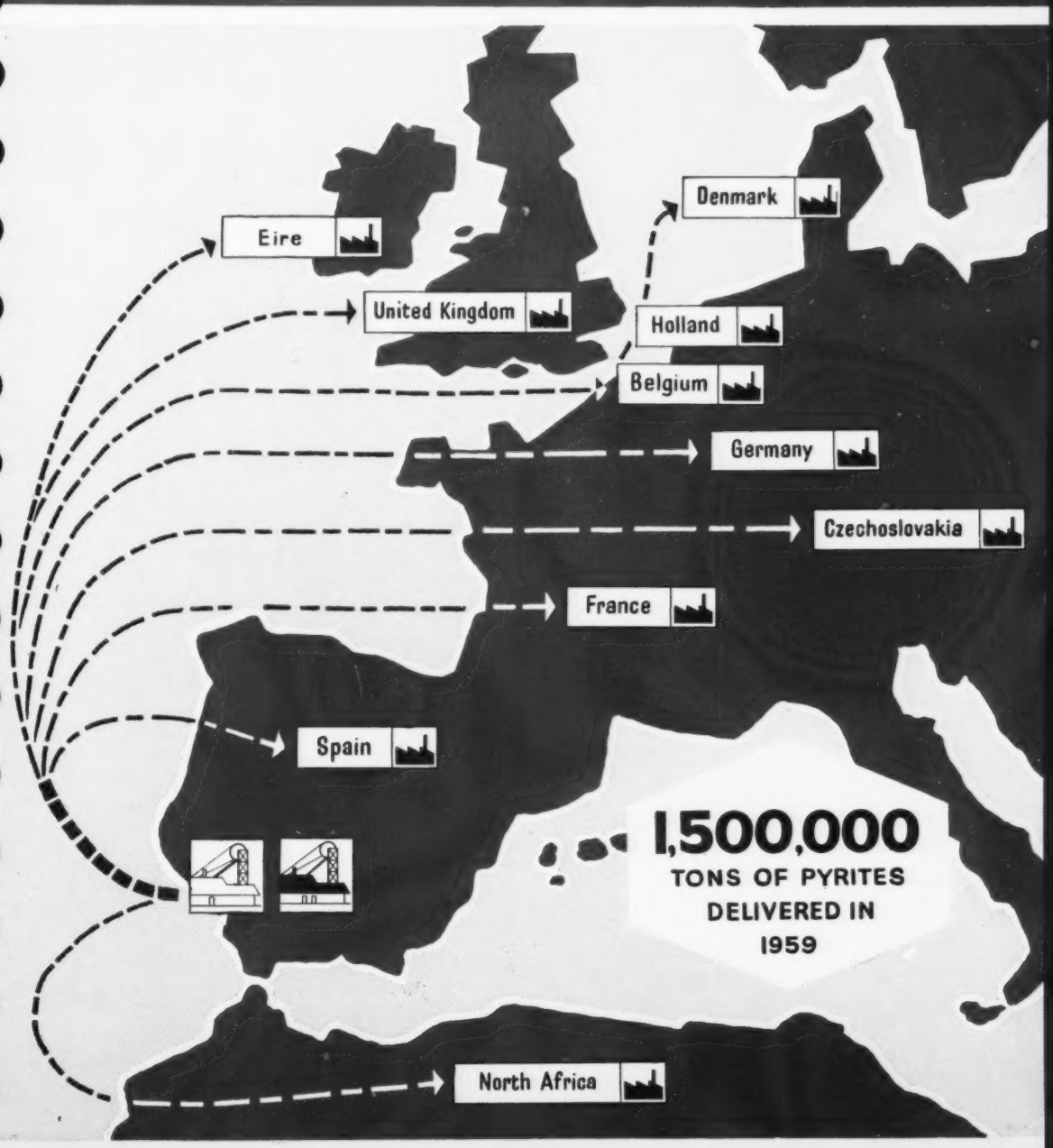
Liquid barge loading facilities at the mainland terminal on Grand Isle proper. Two 1,000-ton liquid sulphur barges are tied up at the dock. The loading tower is between and near the front of the two barges. The small building, centre right is an emergency heating plant for use in keeping sulphur liquid in the underwater line should the offshore plant shut down.

PYRITES

a stable, assured and competitive source of sulphur

The Rio Tinto and Tharsis mines in Spain have supplied Pyrites for over eighty years ~~~~~ Their known reserves are unrivalled

COMPAÑIA ESPAÑOLA de MINAS de RIO TINTO S.A.
THE THARSIS SULPHUR AND COPPER CO. LTD.



Australian Sulphuric Acid Industry in 1959

Outlook is for Increased Consumption of Brimstone

GENERALLY, demand for sulphuric acid in Australia has been increasing in recent years, although there have been some minor setbacks. A steady increase by region has been apparent, with the exception of Queensland, the Northern Territory and Tasmania, where metallurgical projects have caused sharp increases in acid output over the last five years. Whereas the average acid increase for all Australia is estimated at 38%, in Tasmania and Queensland it has been over 100%.

Affecting the overall situation has been the Tariff Board's report on the sulphuric acid bounty. Last June, the Government, after considering the report and the brimstone position, decided not to encourage conversion to local sulphur containing materials (SULPHUR No. 25, July, 1959). This change of policy is related to the now abundant world sulphur supplies. A fresh enquiry is to be conducted by the Tariff Board, to recommend rates of bounty, which, while not designed to encourage further conversion, will honour the Australian Government's obligations to the people who have co-operated in the past.

With the conversion programme in doubt, only limited progress has been made in using indigenous materials and plans for new brimstone units have, in the main, been held in abeyance. As new plants are built it is expected that they will be based on brimstone, except where the natural advantages for use of local material are outstanding; this applies primarily to zinc smelters and oil refineries.

Last year, sulphur consumption in all forms totalled 371,759 tons, thereby surpassing the 1958 consumption of 365,716 tons, the previous record. Sulphuric acid production however, was slightly lower by 8,606 tons at 1,000,458 tons 100% H_2SO_4 (0.9%).

Indigenous sources of sulphur supply contributed noticeably to Australia's requirements and were 53.2% of total sulphur used.

Consumption of various raw materials for sulphuric acid manufacture is estimated to have represented 357,665 tons sulphur in all forms, an increase of 3,865 tons compared with 1958.

Compared with 1958, brimstone consumption at 159,922 tons showed a drop of 20,283 tons (6.1%) but use of pyrites increased from 243,142 tons to 248,841, a 2.3% rise.

A noticeable feature of the raw materials used for acid manufacture is the increased usage of zinc concentrates and other materials. The tonnage of zinc concentrates used has risen by 4,354 tons (3.5%) to 156,501 tons. This is due to the commissioning in the second half of 1958 of the new Risdon, Tasmania plant of

Raw Materials Used for Acid Manufacture

	1959		1958	
Brimstone ..	159,922	18.6%	170,205	20.0%
Pyrites ..	248,841	29.1%	243,142	28.5%
Zinc Conc. ..	156,501	18.2%	152,147	17.8%
Spent Oxide..	10,495	1.2%	12,857	1.4%
Other material	283,309	32.9%	272,094	32.3%
Total Raw materials ..	859,068	100%	850,445	100.0%
Total Acid Sulphur Equivalent ..	357,665		353,800	
Non-Acid Sulphur ..	14,096		11,916	

	H_2SO_4 Production '000 Tons		'000 Tons	
	1959	%	1958	%
Brimstone ..	468	46.8	498	49.4
Pyrites ..	317	31.7	303	30.4
Zinc Conc. ..	122	12.2	118	11.9
Spent Oxide..	11	1.1	13	1.5
Other Material	82	8.2	77	7.8
Total Production	1,000	100.0	1,009	100.0
% Contact ..	46.5		44.2	

Electrolytic Zinc Co. of Australasia Ltd., with a daily capacity of 180 tons. The position with regard to spent oxide is not quite so favourable, however, the tonnage of 10,495 used showing a drop of 2,362 (4.8%) on the 1958 tonnage. The significance of this drop in spent oxide can be related to the fact that less town gas was cleaned. Usage of other materials—lead concentrates, sludges, etc., at 283,309 showed an increase of 11,215 tons, a 2.5% rise.

Acid Production

Last year, production of sulphuric acid stood at 1,000,458 tons, a fall of 8,606 tons on the 1958 total. Contact acid manufacture amounting to 465,200 tons represented 46.5% of acid output compared with 44% in 1958. This trend towards more contact sulphuric acid was indicated in the figures for 1958. Brimstone acid at 468,487 tons shows a drop of 26,622 tons (46.8% as against 49.4% in 1958). Acid from pyrites was up from 303,000 tons (30.4%) to 317,000 (31.7%), from zinc concentrates from 118,000 (11.9%) to 122,000 (12.2%) and from other materials from 77,000 tons (7.8%) to 82,000 tons (8.2%). Production from spent oxide, as is indicated above, has fallen from 13,000 tons (1.5%) to 11,000 tons (1.1%).

Consumption Changes

In 1959 there was a significant change in the pattern of consumption compared with the preceding year. Acid used for superphosphate manufacture declined by 2.2% to 738,742 tons, and that for ammonium sulphate by 16.5% to 76,343 tons. In contrast industrial requirements reflecting the growth of secondary industries increased 16.0% to 183,097, now representing 18.5% of total acid consumption (15.75% in 1958).

Manufacturers

Broken Hill Associated Smelters Pty. Ltd., produce about 65,000 tons a year of 98.5% acid from lead sintering. Commonwealth Fertilisers and Chemicals Ltd., of Melbourne,

Raw Materials	Tons 1959	Tons 1958	% changes
Imported Brimstone for acid making ..	159,922	170,205	—6.1%
Pyrites	248,841	243,142	+2.3%
Zinc Concentrates ..	156,501	152,147	+3.5%
Spent Oxide ..	10,495	12,857	—4.8%
Lead Con. Alk. sludges, etc. ..	283,309	272,094	+2–5%
Sulphuric Acid Production	Tons. 100% H_2SO_4		
Ex Imported Brimstone ..	468,487	498,109	—1.6%
Ex Pyrites ..	316,807	303,414	+2.4%
Ex Zinc Conc. ..	122,119	117,807	+3.0%
Ex Spent Oxide ..	11,179	13,154	—6.5%
Ex Lead Conc. and others	81,866	76,580	+1.6%
Total Prod. ..	1,000,458	1,009,064	—0.9%
Average % by Contact Proc. ..	46.5	44%	
Sulphuric Acid Consumption	Tons.		
for Superphosphate	738,742	756,400	— 2.2%
for Ammonium Sulphate ..	76,343	91,500	—16.5%
for other purposes	183,097	157,900	+16.0%
Total Consump. ..	998,182	1,005,800	— 0.8%
Superphosphate Production	Tons		
Made	2,150,413	2,194,482	— 5.4%
Sold	2,142,231	2,120,914	+ 1.0%
Change in stocks	+8,182	+73,568	—11.9%
Regular Sulphur Use	14,094	11,916	+18.5%

now have acid manufacturing capacity totalling about 180,000 tons a year, from both chamber and contact plants. Raw materials used by this company include pyrites, imported and local-by-product sulphur, spent oxide and waste alkylation acid. About 70% of acid production is being consumed internally for superphosphate manufacture with other chemicals taking smaller quantities.

In South Australia, other than a few thousand tons of brimstone acid produced by Adelaide Chemicals and Fertiliser Co., entire acid requirements of Wallaroo-Mount Lyell Fertiliser Ltd. of Adelaide, for superphosphate manufacture are now obtained from Broken Hill Associated Smelters Ltd., at Port Pirie and for the Birkenhead factory from Sulphuric Acid Ltd., which uses pyrites as source materials.

At Risdon, Tasmania, Electrolytic Zinc Co. of Australasia's installations have a total capacity of 175,000 tons a year (100% H_2SO_4) wholly based on sulphur dioxide from the exit gases of the zinc concentrates roaster.

Installed acid capacity at the Rum Jungle plant of Consolidated Zinc Corporation is 14,000 tons a year. The entire acid output, for which imported sulphur is used, is consumed in the treatment of uranium ore.

Uranium producers, Mary Kathleen Uranium Ltd., Queensland, report that sulphuric acid capacity is 37,000 tons a year, using imported Frasch sulphur. Acid disposal is 100% metallurgical.

At the Geelong plant sulphur is obtained from the adjacent refinery of Shell Chemical (Australia) Ltd. Output will rise at this unit to 30,000 tons a year by end 1960. Total annual acid capacity of Sulphide Corporation (Pty.) Ltd., Melbourne, a subsidiary of Consolidated Zinc Corporation, in 1959 was 92,000 tons a year. The company has three chamber plants using brimstone of 40,000 tons a year capacity, two Chemico contact plants using brimstone with capacity of 12,000 tons a year and one contact plant, using pyrites, of 40,000 tons capacity a year.

Existing acid works in operation.

A.C.F. and Shirleys Fertiliser Pty. Ltd.	Brisbane Q.
	Cairns, Q.
Albany Superphosphate Co. Ltd.	Albany W.A.
Australian Fertilisers Ltd. ..	Sydney N.S.W.
	Pt. Kembla N.S.W.
B.H.A.S. Ltd.	Pt. Pirie S.A.
Commonwealth Fertilisers and Chemicals Ltd.	Melbourne Vic.
Cresco Fertilisers Ltd. ..	Geelong Vic.
	Bayswater W.A.
Cumming Smyth and Lyell	Perth W.A.
Farmers Fertilisers Co. Ltd.	Freemantle W.A.
	Bunbury W.A.
	Geraldton W.A.
Department of Supply ..	Mulwala N.S.W.
Electrolytic Zinx Co. of Asia Ltd.	Risdon Tas.
I.C.I.A. N.Z. Ltd.	Melbourne Vic.
Mary Kathleen Uranium Ltd. ..	Mary Kathleen Q.
Monsanto Chemicals (Aust.) Ltd.	Sydney N.S.W.
Phosphate Co-operative Co. of Australia Ltd.	Geelong Vic.
Shell Refining (Aust.) Ltd. ..	Geelong Vic.
Sulphide Corp. Pty. Ltd. ..	Cockle Creek N.S.W.
Sulphuric Acid Ltd. ..	Adelaide S.A.
Territory Enterprises Pty. Ltd.	Rum Jungle N.T.

Plant Projects

Work on Sulphide Corporation's unit at Cockle Creek,, to operate on zinc smelter gases, is reported to be progressing well. The 250-ton a day sulphuric acid plant which Lurgi AG. are constructing should be completed by mid-1960. It will operate on brimstone until smelter gases are available from the smelter plant which is expected to begin operations early in 1961.

Also well up to schedule is construction of Australian Fertilisers' Port Kembla Unit, which will operate on copper smelter gases.

When Sulphide Corporations' Cockle Creek project is completed it is estimated that Australia's capacity will stand at about 1,360,000 tons, i.e. about 20% reserve capacity will be in hand. Acid demand in 1964/65, it is estimated, will be in the region of 1,250,000 tons.

Trends

While the use of indigenous materials, notably pyrites, was checked in 1958, the position was reversed in 1959, with falls in the tonnage of brimstone used in sulphuric acid production, but despite this, the outlook is for the increased consumption of brimstone in acid manufacture. Non-acid usage is advancing significantly. The more efficient and economic utilisation of the sulphur content of oil refinery gases, and zinc and lead smelters is becoming more noticeable.

The new synthetic rubber plant now under construction at Altona will also take up brimstone; up to 1,000 tons a year. Demand for sulphuric acid for superphosphate manufacture has shown a steady upward trend of recent years. This growth in demand has been checked, however, during the past year. Queensland has shown a marked demand, although this is not as noticeable as in some of the Southern States. Over the next 10 years it is expected that the superphosphate production level will rise gradually by about 3% to 4% a year cumulative and in the case of Queensland by about 8% a year. Similar trends can therefore be expected in sulphuric acid production.

ELIMINATING ARSENIC AND LEAD IN FLUIDISED ROASTING OF PYRITES

Spanish Process gives residues suitable for iron and steel industry: competes with modern multi-hearth furnace

CHANGES in the methods of roasting pyrites have led to marked economic and technical advantages. Until recently it was sufficient to obtain maximum recovery of the sulphur content of the mineral in the form of sulphurous gases which are usually used in the manufacture of sulphuric acid. With brimstone now abundantly available, pyrites as a raw material might well be considered uneconomic unless other by-products can be obtained to provide economic balance. Hence the possible advantages of recovering energy in the form of heat from the reaction and iron oxide in a usable form.

Ideal roasting conditions

Six conditions are required for successful roasting of pyrites : —

a) Production of all the iron as ferric oxide suitable for use by the iron and steel industry and in a form ready for leaching and eventual sintering.

b) Removal of the arsenic and lead from pyrites.

c) Leaving the useful metals, copper and zinc, (impurities in the residues left after roasting) as soluble sulphates.

d) Obtaining gases with the maximum concentration of sulphur dioxide and the minimum of sulphur trioxide.

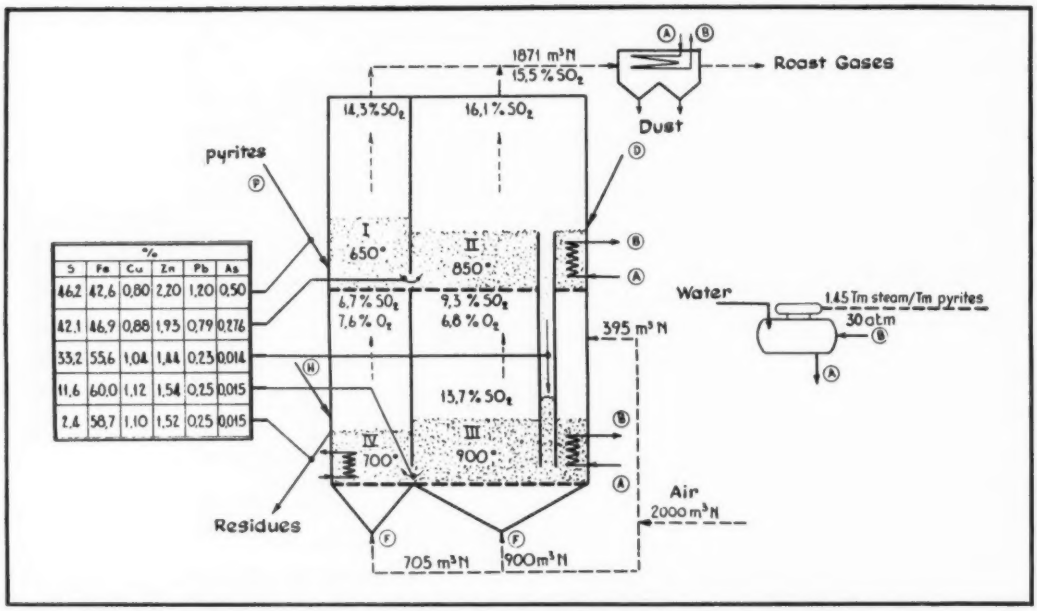
e) Making the maximum use of the heat of reaction.

f) Ensuring the greatest economy in capital expenditure while complying with the preceding conditions.

TABLE I
Principal Functional Characteristics of Furnaces
(Used for Roasting of Pyrites)

Types of Furnaces	(1) Capital outlay for a given roasting capacity	Suitability of residues for the iron and steel industries	Arsenic removal	Sulphation	Concentration of the sulphurous gases	Heat recovery —tons of steam/tons of pyrites
Multi-hearth Without heat recovery	76	Good	Good	Negligible	7—8%	0
Multi-hearth With heat recovery ..	100	Good	Good	Negligible	7—8%	0.8
Rotary kilns ..	75	Good	Passable	Negligible	8—9%	0
Nichols (flash) (2) ..	90	None	None	None	14%	1.5
Fluidised Bed (*a*) One stage ..	71	None	None	Negligible	min. 12%	1.3
(*b*) Two stage : (*b*-1) 2° Total ..	75	Passable	Passable	Negligible	min. 12%	min. 1.2 (3)
(*b*-2) 2° Sulphating	83	Good	Good	Good	min. 12%	min. 1.2 (3)

(1) *100 is taken as the basis of the necessary capital outlay for a given roasting capacity (calculations are based on 160 tons of pyrites/day) in an installation of hearth furnaces with heat recovery boilers.*
(2) *Floatation pyrites are required; if these are not available, an expensive mineral grinding plant would be necessary, which is not computed.*
(3) *Minimum guaranteed limits.*



%					
S	Fe	Cu	Zn	Pb	As
46,2	42,6	0,80	2,20	1,20	0,50
42,1	46,9	0,88	1,95	0,79	0,276
33,2	55,6	1,04	1,44	0,23	0,014
11,6	60,0	1,12	1,54	0,25	0,015
2,4	58,7	1,10	1,52	0,25	0,015

Fig. I Flow diagram of a two-bed process for elimination of arsenic and lead from pyrites

When roasting Spanish pyrites in any furnaces—multi-hearth, rotary kilns, Nichols (flash) and fluidised bed furnaces in the case of Spanish pyrites—it has not been found possible to satisfy all the conditions indicated above.

If heat recovery is not desired (almost a technical heresy to-day), multi-hearth furnaces have the advantage of being well-tried (over a period of 40 years). A considerable capital outlay, however, is required for this type of installation since the furnace capacity required to deal with 1 ton a day of pyrites is 13 times greater than that required for a fluidised bed furnace (Table I). The nearest approach is to be found when employing turbulent roasting carried out in a two-stage fluidised-bed furnace, such as is now in use in Germany, the U.S. and Spain which is preferable.

Piritas Españolas Process

Since Spain has the largest known amount of pyrites in the world, Piritas Españolas (Empresa Auxiliar de la Industria, S.A.) have carried out considerable fundamental research. Spanish pyrites, it should be noted, contain a considerable amount of arsenic and Piritas Españolas have discovered that oxidation of arsenic sulphide (the form in which the arsenic in the pyrites is given off when it comes in contact with the hot turbulent layer) is not due to an excess of air but to the reaction of arsenic sulphide with ferric oxide, chief component of the fluidised bed, resulting in the formation of iron arsenate which remains fixed in the fluidised bed.

As a result of detailed investigations on the elimination of arsenic during roasting, Piritas Españolas have been able to comply with all the conditions listed above. Arsenic and lead are jointly eliminated as they are removed in the inert gases as sulphides, together with the free sulphur, and the formation of ferrous sulphide (pyrrhotite).

Piritas Españolas claim that, provided contact time is sufficient, the last traces of these elements can be removed. By use of certain catalytic agents, however, contact time can be reduced with consequent economic

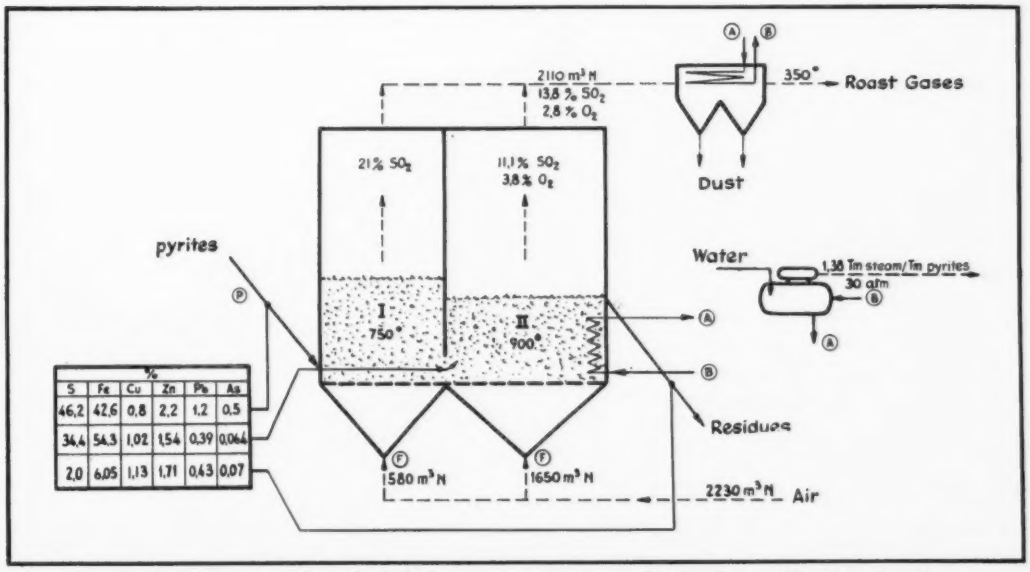
advantages, namely, a smaller furnace for the same output.

Salts and oxides of maganese, alone or mixed with magnesium salts, are used as catalysts (I).

Extraction of copper and zinc present in the residues is possible by direct leaching. In the final roasting-stage recirculated sulphur dioxide and excess oxygen is used. Sulphates of copper and zinc are formed while iron remains as ferric oxide which is insoluble. The residues are then leached and an excellent recovery is achieved, the company claim, without having to reroast with sodium chloride. Cost of leaching is reduced by more than 12s. per ton of residues which means a gain of about 8s. 6d. per ton of pyrites roasted.

Choice of furnace

Using the fluidised bed technique, Piritas Españolas have investigated different types of furnace. The best design is stated to be that of furnace model 22 (2). This furnace is designed to roast iron or copper pyrites containing arsenic and lead, and ensures arsenic and lead-free residues with copper and zinc in the form of soluble salts. (Fig. I). The furnace consists of two sections each having a superimposed bed with its advantages of minimum loss of charge and maximum functional elasticity. Bed I is fed through P, and is fluidised by the gases preheated in the lower bed IV which raises the temperature up to 650°C and in which at least half the sulphur content of the mineral (free sulphur) is oxidised. The solids then pass through the openings in the dividing wall to the second compartment, bed II, which is fluidised by the very hot gases coming from the lower bed III where the temperature is raised to 840°C to 850°C with a substantial amount of arsenic and lead being carried away in the gases. Solids (pyrrhotite) overflow to bed III fluidised by fresh air and recirculated sulphur dioxide introduced through F, thus controlling the combustion of nearly all the sulphur present as sulphide. The residues pass through the openings in the dividing wall to bed IV, in which sulphating conditions prevail, since it is fluidised by a mixture of air



%					
S	Fe	Cu	Zn	Pb	As
46,2	42,6	0,8	2,2	1,2	0,5
34,4	54,3	1,02	1,54	0,39	0,064
2,0	6,05	1,13	1,71	0,43	0,07

Fig. II. Flow diagram of a single-bed process arrangement for the de-arsenification of pyrites

TABLE II.

Economic Comparison of the Processes of Roasting Pyrites
(Cost in £/ton of Useful Pyrite Roasted)

Raw material : Arsenical pyrites
As 0.5%, Cu 0.8%, basis 46% S.
Equivalents : 1£=2.8.U.S.$ =11.76DM =168 Ptas.

Plan capacity 160 tons/day
Working days 330 in the year
Plant location U.K. (Coastal Area)

Roasted with	Multi-hearth furnaces		Fluidised bed furnaces	"P.E." Fluidised bed furnaces	
	Without heat recovery	With heat recovery	One stage	Model 2	Model 22
Unit capacity tons/day ..	40	40	80	80	80
Total cost of plant £/ (1) ..	217,000	285,000	200,000	214,000	248,000
COSTS £/.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Useful pyrites	4 5 0	4 5 0	4 5 0	4 5 0	4 5 0
Pyrites loss ..	6 9	6 9	3 6	3 6	6 9
Operating costs	13 3	13 3	13 0	14 3	17 3
Capital cost	19 9	1 6 0	18 3	19 6	1 2 6
Total £/. ..	6 4 9	6 11 0	5 19 9	6 2 3	6 11 6
CREDITS £/.					
Steam	—	7 6	12 6	11 6	11 6
Residues (2)	1 15 3	1 15 3	—	1 11 3	2 6 0
Total £/. ..	1 15 3	2 2 9	12 6	2 2 9	2 17 6
Cost of equal quantity SO_2 ..	4 9 6	4 8 3	5 7 3	3 19 6	3 14 0
Comparison	Loss	Basis	Loss	Gain	Gain
£/ton pyrites roasted ..	—1.3	—	—19.0	+8.9	+14.3

(1) *The capital expenditure represents the total cost of the corresponding roasting plants with furnaces, boilers (except in the case of hearth furnaces without heat recovery), electrofilters and includes buildings, transport, installations, storage of pyrites and residues on the plant site, platforms, ladders, distribution of electric power, etc.*
(2) *The residues are valued—when they are used in the iron and steel industry—for their iron and copper content.*

and sulphur dioxide gases in the correct proportions. Bed IV also preheats the air which feeds bed I and permits final removal of the sulphur remaining as sulphide in bed III.

Furnace model 21 has been modified to roast pyrites with a low content of non-ferrous metals, in particular copper, where a sulphating stage is unnecessary or where the residues are to be roasted with sodium chloride. With this type of furnace arsenic is stated to be eliminated to less than 0.02% and lead to less than 0.25%, and is therefore suitable for roasting Spanish pyrites. Where it is not required to eliminate lead to such a high degree as, for instance, when the residues are used in the iron and steel industry, the furnace can be of more simple construction. Thus, model 2 designed by Piritas Españolas which can be used for elimination of arsenic (As—0.07%), consists of only adjacent communicating beds. In bed I a temperature of 740°C to 750°C is obtained by controlled combustion which gives good removal of arsenic and the pyrites, in which pyrrhotite predominates, passes to bed II where combustion of most of the sulphur takes place in excess of air at about 900°C. The heat produced is recovered in the form of steam (Fig. 2).

Some lead remains in the residues in an amount greater than is acceptable to the iron and steel industry and analysis shows that these residues are similar to those from multi-hearth furnaces.

In a variation of furnace No. 2, beds I and II are superimposed and this is found to give a better heat recovery.

In its various forms this process has been found to produce residues suitable for the iron and steel industry even where the starting material has a high arsenic and lead content, as is the case with Spanish pyrites. Piritas Españalos claim therefore that their process can compete with the most modern methods of roasting pyrites now in use, e.g., multi-hearth furnaces with heat recovery.

With cupriferous pyrites, the economic results are said to be even more favourable. In Table 2 detailed costs of roasting pyrites are given based on installations in Great Britain and Spain using 160 tons a day of raw material and working 330 days a year, which show the economic advantage of the Piritas Españolas process compared with that of the most modern multi-hearth furnace with heat recovery. In particular, where the original pyrites contains lead, recovery of which by hydrometallurgical process would be uneconomic, the Piritas Españolas process is considered outstanding.

REFERENCES :

(1) Spanish Patent Nos. 208,449, 212,897, 235,440, 2,847,281; British Patent No. 755,259, granted (24.3.53.); D.R.P. 1,015,399; U.S. Patent No. in other countries to Instituto Nacional de Industria, Madrid.

(2) Spanish Patent No. 234,996 (23.4.57); French Patent No. 1,202,993, applied for in other countries.

We are indebted to Piritas Españolas, Madrid, Spain, for the information and illustrations kindly placed at our disposal.

Prices and Trends

DURING the early months of this year the level of world sulphur demand has been high and this was reflected by a widespread increase of output, notably of Frasch sulphur, and further reduction of stocks. Demand strengthened progressively during the latter half of 1959; and what had seemed at first a favourable development in a number of major consumption centres proved to be an almost universal advance prompted by the higher level of sulphuric acid manufacture and also most non-acid sulphur-using industries notably rayon, pulp, rubber and agricultural chemicals. The needs of the fertilizer industry appeared to exert the strongest pressure on sulphuric acid supplies and caused acid productions to reach new high levels. In W. Europe heavy acid demand for ammonium sulphate and superphosphate, in particular triple, coincided with mounting needs of other major acid-using industries, notably viscose rayon, titanium oxide and chemicals, and of many lesser users reflecting the high level of industrial activity. In the U.S.A. strength has not been as pronounced, partly on account of the delay to the start of the fertilizer season, due to adverse weather conditions, and also as the result of the easing of industrial boom conditions which were in evidence during January and February. In addition to the heavy demand for sulphur from the major industrial countries, there has been a significant increase in shipments to South America and Asia, in particular to India. It is estimated that overall sulphur demand in the first quarter advanced about 8% over the corresponding period of 1959.

This state of the current supply picture has not, however, made a tangible impact on the tone of markets nor on the price situation which, under the imminent pressure of new supplies and excess production capacity, remains unstable and weak.

The outstanding feature of the markets, where all major brimstone suppliers continue trying to expand their outlets, especially in marketing territories with the greatest growth potential, is the emphasis on consumer service and quality of product. There is a steady expansion in the U.S.A. of liquid sulphur

deliveries by road, rail and water, which is currently estimated to represent about one-sixth of total deliveries. Facilities for off-colour sulphur purification are being installed and existing ones expanded to provide supplies to customers' specifications. The operation of stockpiles and distribution facilities in or near major centres of consumption, such as at Tampa, where Pan American Sulphur and Texas Gulf Sulphur companies are prominent, or at Cincinnati where Texas Gulf has a major distribution point, have become an integral part of the U.S. sulphur scene.

No Uniform Trend

There is as yet no uniform trend attaching to the importance placed on high purity. Several major brimstone users can show substantial savings whereas others take advantage of the prevailing off-colour sulphur price discount. In Europe the advantages of high purity appear to be more highly valued and this trend contributes to rapidly growing and strong demand for Lacq sulphur. Here, however, the price differential is blurred as Lacq sulphur is sold competitively in relation to U.S. and Mexican Frasch supplies.

Two landmarks, affecting the long term supply picture were passed. On 3rd April the National Energy Board of Canada approved the extension of natural gas exports to U.S.A. and this has now been ratified by the Federal Power Commission of the U.S.A., On the basis of known plans for gas deliveries and treatment plant construction it is expected that Canada's recovered brimstone output will rise to $1\frac{1}{4}$ million tons by the end of 1962. Of more immediate importance is the start of Frasch sulphur production at Grand Isle, Freeport Sulphur Company's off-shore dome, which came on stream on 14th April. This important addition to Frasch sulphur capacity and reserves accentuates the disparity between potential world supply and demand which is entering a critical phase, bearing in mind that the first half of the final stage IV of the sulphur recovery installations at Lacq is operating and full capacity of 1.4 million t.p.a. is due to be reached at the end of this year.

It is evident that the present low and precariously held price level in the U.S.A. and major world markets is wholly attributable to the adverse forward statistical picture and the potential production capacity of major producers resulting in competition for a favourable position in future markets, and not to poor markets or a genuine surplus in current operations. There is little doubt that but for the recent increase in demand, there would have been more widespread erosion of established prices and a further price decline in the major competitive areas. While it is likely that all major primary producers would still remain profitable if prices went lower, most of the small producers would pass their limit of profitability. The determination of the world sulphur price can be expected to rest for many years yet in the hands of the U.S. and Mexican Frasch sulphur producers, notwithstanding that in about three years' time the ratio of Frasch to recovered sulphur production of 5:2 will have changed to about 6:5, if not to parity. In view of the pronounced trend by the majority of sulphur consumers to think in terms of sulphuric acid costs rather than sulphurous raw materials, there is now greater emphasis on avoidance of price disparities between competing sulphur suppliers than pressure for price cuts. Under these conditions fairly conducted price leadership could benefit the entire industry by advancing the depressed prices modestly to a level where profitability would once more reflect the vital part played by the sulphur producers in the economy, while at the same time promoting the consumers' interests in long term stability of prices and supplies.

PRICES

In the United States posted prices remain unchanged at $25 per ton bright sulphur f.o.b./f.a.s. Gulf ports with a discount of $1 per ton for off-colour grades and $1.50 for delivery f.o.r. mine. Freight contributions of $3.50 and other discounts of $1 or more are granted by U.S. producers to their customers

in highly competitive areas, to counter the effect of lower prices and cheaper freight costs of imports of Mexican Frasch sulphur. Delivered prices in Florida, the Atlantic Seaboard and the Eastern and N. Central States range thus from $24 to $26 per ton bright or acid-treated sulphur. The formerly very tense situation has eased slightly as the result of the improved demand, but the threat of a break in prices remains should one or other producer attempt to attract customers by price cutting.

Mexican Frasch sulphur is listed at $23.50 per ton acid treated yellow sulphur f.o.b. Coatzacoalcos. Delivered prices incorporate substantial discounts to meet competition in all markets.

Italian fused sulphur is listed at Lire 18,000 — 19,000 (£10 5s. — 10 17s.; $29.50 — 30.50) per tonne f.o.b. Sicilian ports. In selected markets Ente Zolfi Italiani subsidise the price, but exports even to the favoured Mediterranean and Balkan countries and some others where Italy has bilateral trading arrangements are declining, owing to fierce competition.

Europe in recent months witnessed strong competition between Sulphur Export Corporation (selling on behalf of all U.S. frasch sulphur producers), the two Mexican producers (Pan American Sulphur Co. and Gulf Sulphur Corp.) and Soc. Nationale des Pétroles d'Aquitaine but generally there was no change of earlier price levels. In the most competitive markets — the Low Countries — prices as low as $24.50 per tonne are reported, but most sales are in the range of $26.50—$28.50.

Both United States and Mexican suppliers of Frasch sulphur remain intent on securing long term contractual arrangement in order to safeguard as large a part of the European markets as possible against French recovered sulphur supplies which aided by a freight advantage, are competitive in all European markets. Small parcels of U.S.S.R. sulphur continue to be widely offered, slightly below the lowest reported price in any one market.

Domestic prices of recovered sulphur in European countries have generally remained stable. Based on import prices they incorporate inland delivery charges, premiums for liquid supplies, taxes etc. In Western Germany prices in the Ruhr and at Hamburg of indigenous recovered sulphur at oil refineries and by Ruhrgas A.G. from spent oxide range from DM 115 — 128 per tonne plus turnover tax and handling and service charges. In Belgium and Holland recovered sulphur is sold at B. Fr. 1400 and D. Fl. 100—105 per tonne respectively. In Sweden sulphur recovered from oil shales by Svenska Skifferolje A/B is sold at S.Kr. 158 per tonne, a large proportion in liquid form; competing supplies of Orkla sulphur are priced correspondingly.

Pyrites

The price level of European pyrites is unchanged. Spanish and Portuguese crude pyrites prices remain based on 60s. per tonne f.o.b. basis 48% S for all values. The export value of Cyprus iron pyrites range from 54s–55s per tonne. The high level of steel industry activity and the prevailing good price for copper gives steady support for residue values. Cupreous residues are reported to be priced at 80s–85s per tonne with a firm tendency. Non-cuprous residues of good quality are reported at 75s. f.o. barge, Rotterdam.

SUPPLY

In the United States Frasch sulphur production was maintained at the relatively high level prevailing at the turn of the year of 390,000–400,000 tons monthly. Stockpiles were being reduced by all producers, notably at Port Sulphur, where the Freeport Sulphur Company prepared for the anticipated new supplies from Grand Isle. At Texas Gulf Sulphur Company's new terminal facilities on the Neches River at Beaumont, through which by the end of this year virtually all shipments will be directed, when the company will cease using the Galveston docks, the volume of liquid and solid sulphur deliveries is increasing. A new Frasch sulphur producer, the United States

Sulphur Company, announced the start of sulphur operations at High Island Dome early in April. A production rate of 500 tons daily was reported; the entire output is to be converted to sulphuric acid in a plant situated at the mine.

Recovered sulphur production increased slightly and imports of Mexican sulphur advanced substantially, the latter to a monthly rate of over 60,000 tons. The high level of domestic demand and the exceptionally high export deliveries caused a further reduction of stocks of about ¼ million since the beginning of the year.

In Mexico Frasch Sulphur production in the first quarter reached a new peak of 317,000 tons. Strong overseas and domestic demand caused Pan American Sulphur to raise the level of output at Jallipan to 850,000 t.p.a. The quality of crude output has further improved and to realise the managements aim of producing bright sulphur only, the acid treatment and filtering plant is being enlarged and a sulphuric acid plant built alongside. Gulf Sulphur Corporation has also raised the level of output and production in the first quarter totalled about 58,000 tons, an increasing proportion of which is acid treated in the new plant at the dockside in Coatzacoalcos.

Fused sulphur output in Italy and Sicily has been further reduced to a monthly level of under 8,000 tons. At the same time production of output concentrates of 90–94% S, increasingly used for CS_2 manufacture, has risen and more crude ore is being used in acid manufacture.

In Egypt the operations at Ras Gemsa sulphur mine on the Sinai peninsula are accelerating now that the flotation and concentration plant built by Knapp and Bates Ltd. of London for Semadco has been completed. The 80% S concentrate is refined in a fusion plant of local design and a substantial increase of output is expected this year.

Pakistan will similarly initiate domestic sulphur refining operations at a rate of 30 t.p.d. when an ore flotation and pressure/hot water fusion plant built by Knapp and Bates of London and Burnett and Rolfe of Rochester for Nasir Trading House of Karachi, is brought on stream in the Autumn.

Recovered Sulphur

In the United States production in the first quarter rose to an annual rate of around on 700,000 tons reflecting the rising consumption of gas and greater sulphur removal at oil refineries.

In Canada the rate of recovered sulphur output has risen, it is estimated, to an annual rate of 450,000 tons. The plant of Texas Gulf at Okotoks is reported to be operating near its designed capacity of 130,000 t.p.a. and other recovery plants also, notably Jefferson Lake Petrochemicals, Shell and British American Oil Company also produced more. The decision by the National Energy Board authorising gas exports has activated the companies concerned in the two pipeline projects to the U.S.A. and Jefferson Lake Sulphur Company in particular is engaged in final negotiations for the provision of finance at its Calgary and Savannah Creek gas cleaning and sulphur recovery plants. Although sales, to consumers in Alberta, British Columbia and North West U.S.A. have risen the bulk of the output goes to stockpiles which are estimated to total about 350,000 tons. A recent freight enquiry for Vancouver to India points to the imminence of Canada entering overseas sulphur markets.

At Lacq, Société Nationale des Pétroles d'Aquitaine successfully brought on stream in April the first half of the fourth and last stage of the gas cleaning and sulphur recovery plant. This raises installed capacity to 15 million cubic metres gas and 3,000 tonnes sulphur a day. Current production is reported to be at an annual rate of 800,000 tonnes. Strong demand is reported to be filling the company's order book to the limit of anticipated supplies of about 700,000 tonnes to become available in 1960.

Pyrites

The heavy demand for sulphuric acid in W. Europe was only in part reflected by pyrites

shipments. Spanish pyrites maintained the improvement seen towards the end of 1959 and demand in the home market is rising rapidly. This also applies to Portugal where, however, the Minas de San Domingoes of Mason and Barry Ltd., now no longer exporting, are nearing exhaustion.

In Scandinavia pyrites deliveries advanced in response to demand from the active pulp industry and fertiliser manufacturers; the level of exports appears also to be slightly improved.

Shipments from Cyprus, now the largest pyrites exporter in the world, share in the improved markets.

European pyrites industry suffered a setback when a number of established pyrites consumers recently decided to convert their activities to brimstone E.N.C.K. one of the largest fertiliser producers in Holland, decided to replace its remaining pyrites plant — one half of the works is already based on brimstone — by a 200 t.p.d. brimstone acid contact plant. W. and H. M. Goulding, Eire, also announced the installation of a 200 tons per day brimstone acid plant which it is reported, will consume U.S. Frasch sulphur to be supplied under a long-term agreement. The plant is expected to replace several old pyrites installations in Dublin. In Western Germany where brimstone consumption for acid manufacture in 1959 rose to 40,000 tonnes, this is expected to double this year and account for about 8% of total output.

The decisions to convert to brimstone are unlikely to be based purely on costs as sulphur in pyrites is at present competitive, especially if consumed in furnaces with heat recovery undoubtedly have played a part.

These developments further narrow export outlets for European pyrites producers, for whom their domestic markets assume increasing importance.

Freights

The general tone of freight markets has continued steady and significantly a sizeable volume of laid-up shipping — estimated at about 3 million tons—has returned to commission this year. The effect on sulphur and pyrites chartering has not been uniform. Whereas the longer voyages from the Gulf to Australia and India commanded firm and advancing rates, the transatlantic and Mediterranean rates tended to weaken. The rate from the Gulf of Mexico to the United Kingdom remained at 52s 6d. for liners and tramps, whereas that to the Continent receded to $4.25–4.50. A large proportion of the latter shipments are in vessels of 14,000 tons or more. Earlier this year Freeport Sulphur Company loaded for Sulexco a 22,600 tons vessel, the largest yet employed in the sulphur trade.

Rates from Bayonne for Lacq sulphur continue to be based on 25s f.i.o. for United Kingdom and 21s f.i.o. for North West European ports. Allowing for usual small size vessels — for the U.K. mostly coasters of about 1000 tons and vessels up to 5000 tons for other destinations — these rates represent a freight advantage of about $2 below rates from the Gulf. Pyrites rates from Huelva to N.W. Europe receded to 24s (2s 6d load and 2s 6d/2s discharge); similarly from Cyprus to N.W. Europe rates are now 28s.

Enquiries for a vessel from the United States Gulf to India at $9.25 remain unfulfilled and the current rate is believed to be nearer $11. The evident firmness in rates to the Far East — seen also in Phosphate rates from Morrocco to China and Florida to Japan — is reflected by a recent fixture from the Gulf to W. Australia of $12.77 (¢ 50 loading and current rate discharge).

During the coming weeks a weaker tendency in freight markets is expected.

The Sulphur Institute

With the establishment and staffing of the main office in Washington, the President, Mr. Russel Coleman is initiating positive action in pursuit of the Sulphur Institute's aim to advance the uses of sulphur, from a technical view point. In view of the vast scope of the task, the Institute plans to make the greatest possible use of existing research and intelligence organisations. At the Board's meeting in Paris at the beginning of May, it was decided to locate the European office in London.

BERK'S DEVELOPMENT OF MOLTEN SULPHUR TRANSPORT IN U.K.

IN the course of the last four years F. W. Berk and Co., Ltd., one of the leading chemical manufacturers in the United Kingdom have built up a comprehensive transport and distribution system for sulphur in molten form.

Despite the significant post-war growth of the Company's business and its diversification of manufacturing and merchanting interests which range from the old established manufacture and distribution of sulphuric acid and other heavy chemicals to fine chemicals, mercurials, pharmaceuticals, timber preservatives, licencing of processes, etc., its interest in sulphur continues to play an important part. As one of the U.K. representatives of the Sulphur Export Corporation for the sale of non-acid sulphur—a section of the sulphur market in which demand has in recent years fluctuated between 90,000 and 115,000 tons annually, of which at least 75% is imported material—F. W. Berk and Co., have until last year accounted for approximately one-half and, with the advent of French sulphur supplies in the United Kingdom, are likely to retain about one-third of this market. Some three years ago at the company's plant at Stratford an up-to-date compact unit for rolled sulphur production revived the company's interest in the field of manufacture of various grades of refined sulphur which earlier had been prominent. Emphasis on finely divided dusting sulphurs enhances the scope of the company's Microniser Division which exploits a patent plant and process developed in the late 1930's by the Freeport Sulphur Company. Finally, apart from its use of small quantities of sulphur in the formulation and manufacture of fine chemical products, F. W. Berk and Co., use upward of 10,000 tons brimstone in sulphuric acid manufacture which is based on two Leonard/Monsanto contact acid installations. Progressive modernisations of the sulphuric acid installation, in which up to World War II a part of the sulphur needs were met by spent oxide, resulted in 1955 in the reconstruction of the covered storage for 2,500 tons of crude solid sulphur, and the construction of a new steam-heated melting pit and underground liquid storage.

A Berk tanker carrying molten sulphur

About this time the company started to purchase some of its sulphur requirements in solid form from Esso Petroleum Company's refinery at Fawley. As the sulphur is first recovered in liquid form the then current practice of solidification, breaking-up, transportation and subsequent remelting seemed cumbersome and expensive. Co-operating with a prominent specialist in bulk transport a 14-ton vehicle was developed to carry the sulphur, in hot molten form, from the refinery to the company's acid plants at Stratford; a road journey of 100 miles being involved. This operation proved successful and, as supplies available from oil refinery recovery operations increased, a special tanker fleet was developed. In addition to augmenting consumption at Stratford, the company sought customers who would benefit by receiving their sulphur in molten form. Whereas the original outlet of

indigenous recovered sulphur in solid form had been almost exclusively the "regular" sulphur user, notably carbon disulphide and rubber manufacturers, the principal outlet for the sale of molten sulphur became the sulphuric acid sector.

Because sulphur production at refineries fluctuates considerably, due to variations in crude oil stock and customer demand for end products, the various refineries were glad to have a distributor with the ability to balance any irregularity of supply from other sources and so maintain continuous service to users.

Nowadays F. W. Berk and Co., distribute for all the oil companies in the U.K., producing sulphur. Already the company's sulphur carrier fleet consists of eight tankers, the latest incorporating improvements and modification in design of insulation and heating facilities, and journeys of over 200 miles are regularly made in all weathers including severe snow and ice. It is estimated that in 1959 total sulphur output, i.e. that captively used at refineries or subsidiary chemical companies and that sold through the intermediary of F. W. Berk and Co., amounted to about 55,000 tons. Continued refinery expansion coupled with the demand for purer fuels is increasing the rate of recovered sulphur output, and it may be expected that the volume of sulphur carried in molten form will correspondingly expand.

Current Events

POLAND

Progress at Opencast Sulphur Mine

At Piasceszno the sulphur ore lies relatively near the surface and in consequence this deposit is the first to be exploited. Work on the opencast mine is said to be going ahead rapidly. The 1960 target for sulphur ore to be extracted from it is 170,000 tonnes and that for 1961 is 800,000 tonnes. The average sulphur content of the ore is however only about 29%. Work is now in progress on an ore-processing plant at Piasceszno from which the first pure sulphur will probably be produced in 1961.

The principal difficulty with the Polish sulphur deposits is that the beds are saturated with water having a high concentration of hydrogen sulphide, amounting to as much as 300 milligrammes per litre, and a considerable salt content, amounting to as much as 14 grammes per litre, including sodium chloride up to 11.5 grammes per litre. Two years' experience at Piasceszno has yielded useful knowledge of drainage and water purification methods. Water from the purification plant is now almost free from hydrogen sulphide and may safely be discharged into the Vistula.

The contaminated water is pumped to the top of a packed tower in which the hydrogen sulphide is removed by air flowing in the opposite direction. From here the purified water flows into the river and the mixture of air and hydrogen sulphide is introduced to a second tower in which it meets an alkaline solution of ferric hydroxide flowing countercurrently. In the first phase of the reaction hydrogen sulphide is absorbed by soda. The resulting acidic sodium hydrosulphide immediately reacts with ferric hydroxide to give ferric sulphide, which is then oxidised by atmospheric oxygen to produce ferric hydroxide and sulphur in a regenerative process. The sulphur is separated from the absorption mass by flotation. It is collected in the form of foam and is then colloidally dispersed and may be used for making colloidal hydrophilic sulphur both for agriculture and for the rubber industry.

AUSTRALIA

Gypsum and Clay Soils

An interesting new method for establishing irrigated pastures by the addition of gypsum to the irrigation water has recently been demonstrated in New South Wales by the Commonwealth Scientific and Industrial Research Organisation. It has been found that

as little as one half pound of common gypsum per 100 gallons prevents soil breakdown and the formation of hard surface crusts. Both water absorption and aeration of the soil are improved. The C.S.I.R.O. has developed a machine which dissolves the gypsum at the required rate. It is thought that the discovery is the first step towards the more effective use of heavy clay soils.

The use of gypsum might, however, affect the consumption of single superphosphate, the overwhelmingly predominant phosphatic fertilizer in Australia. One of the advantages of single superphosphate is that it augments the soil's sulphur content. As this could be achieved by gypsum alone it is clear that the use of single superphosphate on lands irrigated in this way might make the soil excessively acidic. Thus there is a possibility that the growth in the demand for single superphosphate and hence the growth in the demand for sulphur might be adversely affected.

Although triple superphosphate in theory contains no sulphur, it is more apt than single superphosphate to produce excessive soil acidity. Hence the use of gypsum might make its application undesirable also. In this event the use of ground phosphate rock might become established, and high analysis complex fertilizers might be applied where the intensity of cultivation warranted.

INDIA

Durgapur H_2SO_4 plant on stream

On stream is the 60 tons-a-day sulphuric acid plant forming part of the plant at the Durgapur steel project. Rated capacity of the plant was achieved within a few days of commissioning. The plant was designed, engineered, and constructed by Simon-Carves Ltd., one of the member companies of the I.S.C.O.N. consortium at Durgapur.

Raw material for acid production is rock sulphur of high purity, which is burned to produce sulphur dioxide. This in turn is converted into sulphur trioxide in the presence of a catalyst, and is absorbed in sulphuric acid. This acid is then diluted with water to produce acid of 98.5% strength.

Surplus heat from the burning of sulphur and the catalytic conversion of sulphur dioxide to sulphur trioxide is utilised to produce approximately 5,000 lb. of steam an hour. Part of this steam is used in the plant for sulphur-melting and other purposes, the rest being passed into the steelworks' steam mains. The sulphuric acid produced will be used primarily for the production of sulphate of ammonia.

U.S.A.

Gas Removal Plant for Transwestern

First U.S. installation to use the Giammarco-Vetrocoke process for acid gas removal is that of Transwestern Pipeline Co. Now ready for operation near Fort Stockton, Texas, the plant was designed and constructed under licence by Brown and Root Inc. It will treat 180 million cubic feet daily of 1,050 p.s.i.g. natural gas containing 28% hydrogen sulphide.

The unit will produce an anhydrous pipeline sales gas essentially free of H_2S and with less than 28% of carbon dioxide. It will use less than 4 million cubic feet of sour gas daily to develop installed generating capacity of only 1,800 kW. and 120,000 lb./hr. of steam at 600 p.s.i.g. and 750°F.

Start of the plant will be timed to coincide with the completion of Transwestern's pipeline from Texas to California.

Susquehanna Doubles Acid Capacity

Susquehanna - Western's new sulphuric acid unit at Riverton, Wyoming, doubles the company's and Wyoming's H_2SO_4 capacity to 75,000 tons a year. The new unit, now in full production, was constructed by Susquehanna Engineering in four months and is fully automated. Sulphur is obtained from local Wyoming suppliers who recover it from sour gas. Acid is produced by burning pure sulphur, then converting the resulting gases. Ore (mainly uranium) processing mills in the Wyoming area are expected to consume a substantial amount of the new unit's output.

Major Sulphur Producers Reports on 1959 and the Future

....."Competition in the sulphur industry remains keen, and production from new facilities — existing or in prospect — in Mexico, France and Canada, probably will prolong the current period of excess sulphur supply. There are many reasons, however, for optimism for the future of this low-cost commodity."

Charles A. Wight
President
Freeport Sulphur Co.

....."It is expected that sales during 1960 will compare favourably with movements during 1959. Economic conditions should continue to improve, with consequent acceleration in consumer demands. If added world-wide requirements, for sulphur, continue in percentages commensurate with increased consumption during 1959, then the industry is assured of another record-breaking year."

Harry C. Webb
President
Pan American Sulphur Co.

....."Profitable operations are dependent upon increased production and sales volume, reduced royalty and tax payments, and most important of all, upon restitution of sulphur prices to an economic level." Regarding world sulphur sales. "There are prognostications indicating a 5% increase for 1960".

William Bellano
President
Gulf Sulphur Corporation

Freeport's Sulphur Tonnage Sales Exceeded those of 1958: but production was down

DOMESTIC consumption of sulphur in the U.S. increased to an all-time record level, reversing the recessionary trend in 1958 and exports by the U.S. sulphur industry reached almost to the record level of 1956. These trends are noted particularly in regard to one of the major U.S. sulphur producers—Freeport Sulphur Co.

Tonnage sales of Freeport sulphur exceeded those of 1958, totalling more than 2.1 million tons. Dollar sales of suphur, however, did not increase proportionately as intense competition in some markets necessitated lower sulphur prices. In domestic markets the price became firmer during the latter half of 1959, and the market situation is reported to be more stable.

Freeport's production was somewhat less than 2 million tons, and compares with that of the previous year. There was, however, a considerable reduction in stockpiles of mined sulphur. Grande Ecaille and Garden Island Bay mines were the main source of the company's sulphur and except for a small amount of sulphur recovered from petroleum refinery gas, remaining production was obtained from the two smaller Louisiana mines — Chacahoula and Bay Ste. Elaine. The latter was shut down in December last, its reserves exhausted after seven years of operation.

At Freeport's Grand Isle mine in the Gulf of Mexico, sulphur production began this April. This is the first offshore sulphur installation in the history of the industry. It

increases underground reserves to the highest point in the company's history and will give it the greatest productive capacity it has ever had.

It is planned to postpone production at the company's other new Louisiana property, Lake Pelto. The barge-mounted mining plant formerly employed at Bay Ste. Elaine has been moved to this site, and placed on a stand-by basis.

Present sulphur position

Competition in the sulphur industry remains keen, reports the Chairman, Mr. Langbourne M. Williams, and production from new facilities — existing or in prospect — in Mexico, France and Canada, probably will prolong the current period of excess sulphur supply. He is optimistic, however, about the future of sulphur. New and wider uses for sulphur and its chief derivative, sulphuric acid, are constantly being developed, he notes. In the past decade, for instance, there has been a sharp rise in sulphuric acid requirements for key intermediates used in the manufacture of aerosol sprays, synthetic detergents, air-conditioner coolants and petroleum catalysts, and for the processing of metallic ores, an application which Mr. Williams suggests will expand considerably in the future.

Of the older uses of sulphur and sulphuric acid, the most important is the production of fertiliser, a market which "must inevitably grow as crop production is increased to feed a rapidly multiplying world population".

Finances

Net earnings for Freeport Sulphur for 1959 were the highest in the company's history. After all charges including depreciation, amortisation and provision for taxes, earnings amounted to $14,477,796 compared with $13,084,067 in 1958. Gross sales, however, a $53,233,634 were down on last year's total of $55,341,986.

During 1959, the outstanding shares of common stock were split three-for-one, and, on this new basis, 1959 earnings amounted to $1.93 a share compared with 1958 earnings of $1.74 a share. The increase in earnings was due principally to higher interest income and to a greatly reduced provision for taxes resulting from filing a consolidated Federal income tax return for the company and wholly-owned domestic subsidiaries.

Dividend payments on the new basis totalled $1.20 a share in 1959, compared with $1.00 a share in 1958. A dividend of 30 cents was paid in March 1960.

Record Year for Pan American Sulphur

DURING 1959, new records were achieved by Pan American Sulphur Co. and their Mexican subsidiary Azufrera Panamericana, S. A. de C. V., in total production, total net sales and total tonnage shipped of sulphur, despite continued intense competition, further softening of prices, and world-wide over-supply of product. The year ended with a high degree of optimism for the future, due to unusual increases in demand, both from the viewpoint of U.S. consumption as well as general increased demand throughout the world. The steel strike, notes Mr. Harry C. Webb, president of the company, caused expected uncertainty on the part of customers and producers alike, but over-all sales results were satisfactory.

Production and sales

Production during the year totalled 887,000 long tons and retained inventory on 1 January, 1960, amounted to 580,000 tons. Total tonnage shipped resulted in net sales amounting to $17,869,140, compared with net sales of $17,318,113 during the year 1958, and constitute a record. Movements by the company's Mexican subsidiary during January 1960, amounted to 104,000 gross tons, the

greatest monthly shipments during the company's history.

Industry inventories remain at a safe, but conservative figure. Pan American Sulphur's total stockpile of 580,000 tons will be increased slightly during 1960 and it is anticipated that approximately 900,000 tons will be produced.

High-Purity Sulphur

Quality of PASCO'S product will be improved. Current research and development programmes include the immediate construction of a sulphuric acid plant at Jaltipan with sufficient capacity of acid output necessary to ensure one hundred per cent bright production of 99.9 purity. To sustain their programme of product quality and service improvement, the company has increased exploration and development costs from $28,859 in 1958 to $94,906 in 1959, and will continue this development effort during 1960 and future years to ensure customers a better product and quicker delivery.

Construction activities

A major highlight of 1959 operations was the completion of PASCO'S Tampa, Florida, liquid sulphur terminal, the first installation of this kind in the area. The companion dry bulk installation, with assured inventory of more than 40,000 tons was complete during last March and is now in service. This facility will assure customers of liquid or dry bulk products at all times, to be delivered in tank truck, railroad tank cars, dry bulk truck carriers or railroad gondola cars. Total investment is estimated at $700,000.

Finances

As a result of continued profitable operations, the working capital of the company increased to over $10 million at 31st December, 1959, after providing for installments on the Export—Import Bank notes maturing in 1960. Net cash flow during the year of $4,293,048 (consisting of net income of $3,462,400 provision for depreciation, depletion and amortization of $640,122 provision for income taxes payable in future years of $150,000 and sales of capital stock pursuant to option agreements of $40,526) was utilised

i) to reduce the debt to the Export-Import Bank by $760,667, (same).

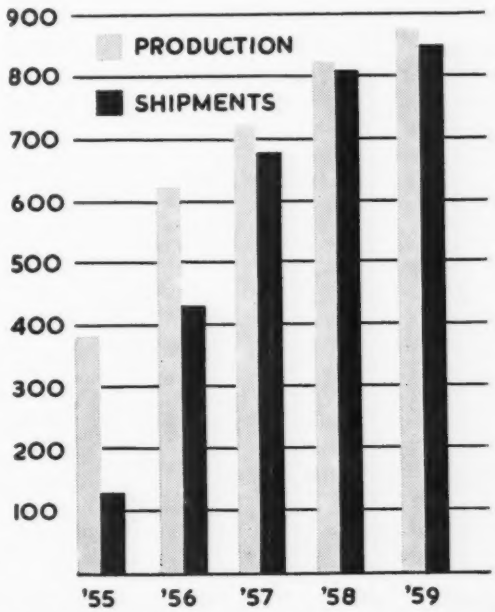
ii) to redeem $90,500 ($323,200) principal amount of debentures.

iii) to pay cash dividends of $1.00 (80 cents) per share or a total of $2,260,792 ($1,687,034).

iv) to provide for capital expenditures totalling $571,082, including construction of the company's sulphur terminal at Tampa, Florida, as well as minor replacements and improvements of equipment.

v) to increase working capital and prepaid expenses by $610,007 ($1,774,975).

Working capital has been increased by an additional $323,200 through elimination of current sinking fund requirements on debentures



Pan American's sulphur production and shipments 1955 — 1959

as a result of the conversion of approximately $3.3 million of the debentures into capital stock during the year. After the regular semi-annual principal payment made on the Export—Import Bank notes in February, 1960, the long-term indebtedness of the company (including current installments) has been reduced to $1,994,467, ($6,140,033) consisting of the balance of the Export—Import Bank notes of $760,667, ($1,521,333) and outstanding debentures of $1,233,800, ($4,618,700). Total investment in capital assets has increased to $13,076,552. No further principal payments on the debentures will be required until 1967, since the amount of debentures which have been converted into capital stock is sufficient to satisfy all sinking fund requirements.

Share earnings for 1959 amounted to $1.50, based on 2,307,311 shares, an increase over 1958 of 187,894 shares, including the additional total created through the conversion of debentures and payment of a 2% stock dividend. On 17th February, 1960, the board declared the usual 25% cash quarterly dividend, which was paid on 30th March.

The Future

Sales during 1960 are expected to compare favourably with those of 1959, and continued improvement in economic conditions with consequent acceleration in consumer demands is indicated. Also, if world-wide requirements for sulphur continue in percentages commensurate with the increased consumption noted during 1959, then the sulphur industry, according to Mr. Webb, is assured of another record-breaking year.

Berk's 45% Interest in Spencer Chapman

One of Britain's oldest inorganic acid manufacturers, and the first to make sulphuric acid by the contact process — Spencer Chapman and Messel Limited — was recently acquired by Borax (Holdings) Limited, so giving control of the company which has supplied Borax's operating subsidiary, Borax Consolidated Ltd. for more than 60 years. The bid also gives them control of Spencer Chapman's 84% holding in Theodore St. Just and Co. Ltd. who make organic chemicals in the Manchester area.

Also a bidder for Spencer Chapman capital was F. W. Berk and Co. Ltd. who later approached Borax. Because of their mutual interests in the heavy acid field and in organic chemicals, it was considered that it would be advantageous to both companies to have an interest in Spencer Chapman. Borax, therefore, agreed as a result of a revised offer to sell to Berk, at the price they paid, 45% of the shares acquired in Spencer Chapman. Cash price for the whole of the issue capital is £1,510,000; the 45% holding will be sold to Berk for £679,500.

The businesses of Spencer Chapman and St. Just will continue to be operated on an independent basis under their own boards and managements with representatives of Borax and Berk.

Consolidated profit of Spencer Chapman and St. Just, after depreciation and before tax for the year ended 31 March, 1959, was £203,704, and it is estimated that the profit for the year ending 31 March, 1960, will reach the 1959 level. In their annual report published in April, Berk report an all-round expansion in their activities, with group sales the highest yet recorded — totalling £8,344,100, and an increase of 12% over the preceding year. A particular point of interest is the substantial growth in the quantity of molten sulphur handled by the company for the major oil companies (see page 34).

Production Increased at Gulf Sulphur, but Profits Lower

OPERATIONS for 1959 in Mexico of the Gulf Sulphur Corporation, Houston, Texas, resulted in a net loss of $168,138 as compared with losses of $530,218 for 1958 and $1,250,437 for 1957. Severe price competition within the general market areas supplied by the company was noted and Mr. William Bellano, president, in the company's annual report for 1959, emphasises that "profitable operations are dependent upon increased production and sales volume, reduced royalty and tax payments, and most important of all, upon restitution of sulphur prices to an economic level".

Many of the plant improvements started in 1958 were completed and have resulted in lower operating costs, reduced administrative expenses, better product quality and increased customer service.

Production and Shipments and Prices

Sulphur production in 1959 was increased to 285,798 tonnes as compared with 267,309 tonnes for 1958 and 181,255 for 1957. During the last quarter of 1959, however, output was reduced in order to control inventories at 100,000 tonnes.

Shipments at 208,251 tonnes were lower when compared with 279,723 tonnes for 1958. Principal factors in the reduced sales were lack of a competitive bright yellow product, price cutting and increased production of bright sulphur from France. Mr. Bellano expected 1960 output of French sulphur to be doubled to 1,400,000 tons; recovered sulphur production from Western Canada has not as yet affected the market area directly served by Gulf Sulphur, but the president points out that as gas output increases greater supplies of recovered sulphur will become available for world trade. Volume of world sulphur sales, in all forms, increased substantially in 1959 to over 16 million tons.

Price competition became more severe as the year progressed and reached a climax during the second half when a freight equalisation and discount plan placed into effect by some of the larger producers. In the last quarter of 1959 ocean shipping rates increased as much as 25% causing further aggravation of an already sensitive price structure.

In this context Mr. Bellano emphasised that whereas historically the industry has quoted prices F.O.B. point of origin, recent trends, brought about by wider geographical distribution of sulphur materials, are toward delivered price quotations. In addition the trend towards stockpiling within reach of strategic markets continues. Gulf Sulphur have established a bulk sulphur stockpile in the Tampa area, and are seriously considering several others, Mr. Bellano reports.

Capital Expenditures

During 1959 approximately $493,000 was spent on property, plant and equipment. The improvement programme, begun in 1958 to provide changes and additions in mining and handling facilities, represented a total outlay of $1,300,000 of which $110,000 remains to be paid on installment terms extended by suppliers.

A development programme was started early in 1959 to produce a bright yellow sulphur that would be competitive, both in quality and colour with the French product. In September last year the filter plant was converted to the new acid treatment process and production of filtered sulphur was discontinued. Sales acceptance of bright sulphur has been good and Gulf Sulphur plan to increase production as required.

Capital expenditures for 1960 are estimated at $70,000, to be applied against normal equipment replacement, additions to the bright sulphur plant and exploration for new reserves.

Reserves

Since commencement of operations in April 1956, 850,000 tonnes of sulphur have been produced from the Salinas structure. Reserves measured and inferred, remaining in this deposit are estimated to be 5,850,000 tonnes. Company concessions total 12,000 acres and a 'modest' exploratory drilling programme is underway to provide more information and guidance.

Royalties and Taxes

Royalty payments on production and sales constitute the largest single cost item in operations. Through negotiations some of the royalties have been reduced so that payments now total $5.45 per ton as against $6.30 per ton at the start of 1959. Accrued royalty payments at the year end amounted to $889,094. Direct levies such as the 1.1% production tax, the Free Port in and out tax and the technical services tax total $0.57 per tonne.

Finance

Sales of sulphur were valued at $4,228,847 in 1959 as against $5,667,417 in the previous year. Net income totalled $16,714 compared with $72,918 in 1958 but after depreciation, depletion and amortisation, there was a net income loss for the year of $584,882 ($703,136 in 1958). The year started with an earned surplus deficit of $2,883,768 ($2,253,550 in 1958) and at the end of the year this loss was $3,051,906 (£883,768).

General position

This year Gulf Sulphur expect to maintain production in line with shipments. Due mainly to the introduction of their 99.9% bright yellow sulphur, sales for the first quarter of 1960 are estimated at 85,000 tons, an improvement of 85% over the similar period last year. Volumes of world sulphur sales, in all forms, are expected to show a 5% increase this year, Mr. Bellano indicates, but lower sales prices prevail so that net back realisation is expected to be down more than 2%. No new major additions are planned for 1960 by Gulf Sulphur.

Tangyes Pump for Hot Dilute Sulphuric Acid

DILUTE sulphuric acid is amongst the most corrosive of liquids. It is claimed that pumps having their " wet " parts made of ceramics or lined with porcelain or rubber are either too fragile or wear out too quickly. With all liquid-contact parts in hard lead there is a high resistance to corrosion, and in addition any wear or damage can quickly be made good by the fusion of new lead where required.

Tangyes Limited of Smethwick, Birmingham, who make a range of pumps for dilute sulphuric acid, have recently brought out a new design incorporating several features of interest. Vertical splitting of the pump casing permits rapid inspection of the impeller and passages. The housing of the main bearings supports a substantial pump impeller shaft, the bearings being well isolated from the pump hydraulic unit. The shaft enters the pump via a soft packed stuffing box which is pressure-fed with grease. An additional supplementary gland is fitted, and this traps the normal gland leakage. A thrower arrests any minor seepage from the supplementary gland. The bearing housing incorporates a micro-axial spindle adjustment to enable accurate setting of the impeller to be carried out with ease. The shaft, which is of " Monel " metal, is supported in the pump body by a rear-bearing bush, which is of an acid-resistant plastic. Renewable sleeves are fitted in the internal bearings and also where the shaft passes through the stuffing box. Replacement of these is cheaper than changing the shaft.

For pumps with a 2 in. or 3 in. discharge, a single entry design is also available. Double entry pumps are made having a discharge of up to 8 in. Output ranges from 50 gallons to 1,800 gallons of liquid per minute with a head of up to 80 ft.

UNITED STATES

	PRODUCTION		STOCKS		EXPORTS	IMPORTS*
	Frasch	Recovered	Frasch	Recovered		
1956	6,427,229	480,980	3,936,450	119,446	1,651,597	203,044
1957	5,491,210	519,078	4,422,548	157,075	1,561,093	484,680
1958	4,644,812	619,594	4,442,066	177,271	1,575,071	565,690
1959	4,553,634	650,763	3,809,708	140,246	1,611,908	612,474
1959 April	390,757	48,929	4,248,242	169,605	137,371	56,404
May	389,212	56,964	4,155,945	166,350	148,526	63,281
June	346,887	58,679	4,078,807	162,911	125,337	91,659
July	312,192	53,636	4,008,018	159,944	175,316	59,926
August	368,561	54,169	3,875,792	156,342	178,010	49,928
September	399,157	52,050	3,814,932	154,211	148,968	68,825
October	483,086	49,950	3,899,128	145,185	125,474	29,091
November	408,481	51,623	3,833,537	142,157	141,442	31,415
December	411,531	59,455	3,809,708	140,246	160,538	31,461
1960 January	388,630	54,907	3,845,754	133,860	116,523	79,294
February	366,357	57,546	3,811,384	131,466	Not available	Not available

Official Bureau of Mines Data (long tons of 2,240 lbs.) * Imports of sulphur from Mexico only.

SULPHUR EXPORTS

Long Tons

	1958	*1959*	Difference
Canada	332,262	287,500	—44,762
Guatemala	100	99	— 1
Costa Rica	31	33	+ 2
N. Antillies	5,000	5,000	
Brazil	97,007	126,391	+ 29,384
United Kingdom	279,053	273,230	— 5,823
Belgium	100,180	53,675	—46,505
France	99,065	85,945	—13,120
Germany West	42,361	86,290	+ 43,929
Sweden	18,367	—	—18,367
Austria	25,717	10,000	—15,717
Norway	3,141	—	— 3,141
Iran	6,000	2,260	— 3,740
Philippine Republic	1,944	900	— 1,044
Australia	124,604	123,084	— 1,520
Algeria	23,560	9,000	—14,560
Union of S. Africa	65,900	61,385	— 4,515
India	114,028	124,699	+ 10,671
Venezuela	2,080	3,291	+ 1,211
Pakistan	3,065	2,317	— 928
Indonesia	7,800	7,700	— 100
Korean Republic	1,844	913	— 931
New Zealand	39,854	84,039	+ 44,185
Uruguay	6,133	3,262	— 2,871
Argentine	32,852	32,776	— 76
Netherlands	10,400	41,799	+ 31,399
Switzerland	40,905	34,700	— 6,205
Poland	2,500	22,320	+ 19,820
Lebanon	2,499	1,000	— 1,499
Cuba	11,750	30,943	+ 19,193
Peru	2,991	4,909	+ 1,918
Finland	43,894	12,600	—31,294
Yugoslavia	2,000	2,000	
Greece	999	—	— 999
Israel	7,500	25,069	+ 16,569
Canary Islands	4,428	4,920	+ 492
Suadi Arabia	90	1,532	+ 1,442
Aden	100	—	— 100
Morocco	7,700	—	— 7,700
Bahrain	371	521	+ 150
Paraguay	29	1,606	+ 1,577
Spain	4,921	—	— 4,921
Honduras	36	71	+ 35
Nicaragua	—	1,446	+ 1,446
Columbia	—	314	+ 314
Syria	—	49	+ 49
Tunisia	—	15,833	+ 15,833
Denmark	—	1,000	+ 1,000
Sweden	—	9,825	+ 9,825
Czechoslovakia	—	10,600	+ 10,600
Ceylon	—	109	+ 109
Burma	—	545	+ 545
Mexico	—	20	+ 20
Dominican Republic	—	399	+ 399
Taiwan	—	4,133	+ 4,133
Egypt	—	36	+ 36
Total	**1,575,071**	**1,611,908**	**+ 36,837**

MEXICO

PRODUCTION	*Pan American Sulphur Co.*	*Gulf Sulphur Corporation*	*PEMEE and Texas Gulf Sulphur*	*Negociacion Minera de Azufre SA*	*Total*
1959 January	66,862	23,004	15,000	1,400	106,266
February	67,184	24,424	14,060	1,422	107,090
March	72,941	26,620	15,620	1,500	116,681
April	63,188	25,237	16,000	1,500	105,925
May	69,140	23,093	15,200	1,591	109,024
June	73,166	25,144	14,500	1,500	114,310
July	87,643	26,833	16,000	1,500	131,976
August	78,231	25,270	17,000	1,500	122,001
September	72,577	23,407	17,000	1,600	114,584
October	83,987	20,158	16,480	1,500	122,125
November	75,669	20,719	16,800	1,500	114,688
December	75,755	18,559	17,000	1,500	112,814
1960 January	72,758	21,127	17,500	1,500	112,885‡
February	68,518	17,885	7,750†	1,500	99,653
March	71,242	18,740	7,312	1,500	98,794

† Texas Gulf Sulphur ceased operations.
‡ Includes 500 tons produced by Texas International Sulphur Company.

NORWAY

PYRITES EXPORTS

Metric Tons

	1958	1959
Denmark	45,593	56,340
Sweden	103,752	77,836
West Germany	155,025	216,598
East Germany	41,584	*
Czechoslovakia	21,771	*
France	11,024	*
Netherlands	10,405	*
Others	6,272	57,386
Total	**394,826**	**408,154**

* Included under others.

SULPHUR EXPORTS

Metric Tons

	1958	1959
Finland	20,391	21,389
Sweden	31,475	38,820
Spain	—	5,000
Others	3,303	249
Total	**55,169**	**65,458**

NETHERLANDS

PYRITES IMPORTS

Metric Tons

	1958	1959
Ireland	538	945
Norway	8,782	19,766
Portugal	103,691	100,159
Spain	8,195	22,820
Italy	86,931	170,721
Greece	12,510	14,430
Cyprus	112,627	110,616
Total	**333,384**	**379,579**

CRUDE SULPHUR IMPORTS

Metric Tons

	1958	1959
U.S.A.	21,915	30,878
Mexico	42,957	19,610
West Germany	—	157
France	—	7,763
Total	**64,890**	**58,408**

REFINED SULPHUR IMPORTS

Metric Tons

	1958	1959
Belgium/Luxembourg	166	162
United Kingdom	36	45
West Germany	668	1,048
France	—	90
U.S.A.	—	6
Total	**928**	**1,387**

WEST GERMANY

SULPHUR IMPORTS

Metric Tons

	Jan.–Dec. 1958	Jan.–Nov. 1959
France	13,046	28,682
U.S.A.	42,286	53,969
Mexico	8,716	5,979
Total	**64,048**	**88,630**

PYRITES IMPORTS

Metric Tons

	Jan.–Dec. 1958	Jan.–Nov. 1959
Finland	22,156	21,861
Greece	3,101	—
Yugoslavia	60,965	61,262
Norway	156,414	186,352
Portugal	59,451	61,254
Sweden	11,922	—
Spain	524,463	474,895
Turkey	30,108	41,020
Canada	33,177	—
Cuba	36,081	24,943
Cyprus	387,897	365,349
Others	1,765	—
Total	**1,327,872**	**1,236,687**

BELGIUM

PYRITES IMPORTS

Metric Tons

	1958	1959
Portugal	109,702	66,499
Spain	87,952	116,896
Cyprus	59,641	82,170
Total	**266,765**	**270,256**

CRUDE SULPHUR IMPORTS

Metric Tons

	1958	1959
Netherlands	1,304	8,314
France	—	23,519
U.S.A.	88,446	74,484
Mexico	—	29,113
Total	**96,167**	**135,722**

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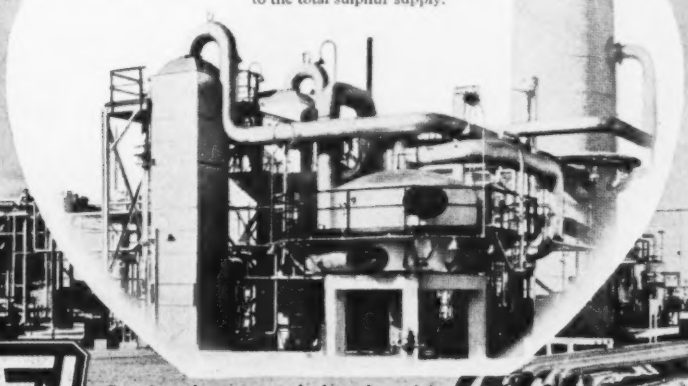

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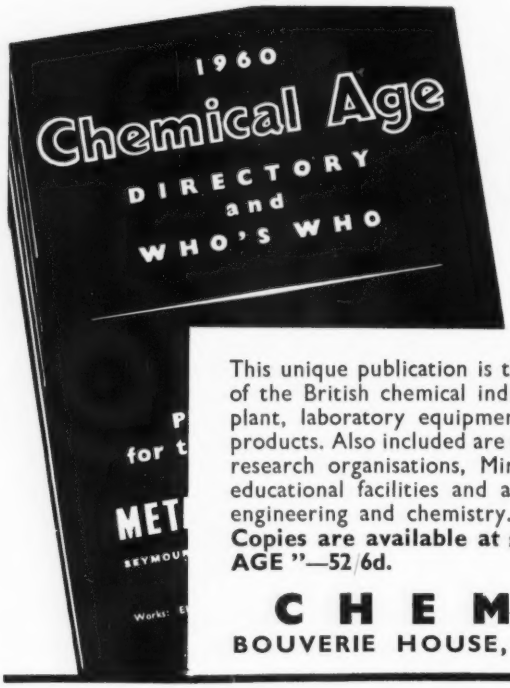

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